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LAND RESOURCE INVENTORY SOCIO-ECONOMIC STATUS OF FARM HOUSEHOLDS FOR WATERSHED PLANNING AND DEVELOPMENT

MACHINAHALLI-1 (4D4A3O1e) MICRO WATERSHED

Shirahatti Taluk, Gadag District, Karnataka

Karnataka Watershed Development Project – II

SUJALA – III

World Bank funded Project

The World Bank

ICAR – NATIONAL BUREAU OF SOIL SURVEY AND LAND USE PLANNING

ICAR - NBSS & LUP

WATERSHED DEVELOPMENT DEPARTMENT
GOVT. OF KARNATAKA, BANGALORE

About ICAR - NBSS&LUP

The ICAR-National Bureau of Soil Survey and Land Use Planning (ICAR-NBSS&LUP), Nagpur, a premier Institute of the Indian Council of Agricultural Research (ICAR), was set up during 1976 with the objective to prepare soil resource maps at national, state and district levels and to provide research inputs in soil resource mapping and its applications, land evaluation, land use planning, land resource management, and database management using GIS for optimising land use on different kinds of soils in the country.

The Bureau has been engaged in carrying out soil resource survey, agro-ecological and soil degradation mapping at the country, state and district levels for qualitative assessment and monitoring the soil health towards viable land use planning. The research activities have resulted in identifying the soil potentials and problems, and the various applications of the soil surveys with the ultimate objective of sustainable agricultural development. The Bureau has the mandate to correlate and classify soils of the country and maintain a National Register of all the established soil series. The Institute is also imparting in-service training to staff of the soil survey agencies in the area of soil survey, land evaluation and soil survey interpretations for land use planning. The Bureau in collaboration with Panjabrao Krishi Vidyapeeth, Akola is running post-graduate teaching and research programme in land resource management, leading to M.Sc. and Ph.D. degrees.

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TO OBTAIN COPIES,

Please write to:
Director, ICAR - NBSS & LUP,

Amaravati Road, NAGPUR - 440 033, India

Phone : (0712) 2500386, 2500664, 2500545 (O)

Telefax : 0712-2522534

E-Mail : director@nbsslup.ernet.in

Website URL : nbsslup.in

Or

Head, Regional Centre, ICAR - NBSS&LUP, Hebbal, Bangalore - 560 024

Phone : (080) 23412242, 23510350 (O)

Telefax : 080-23510350

E-Mail : nbssrcb@gmail.com

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PREFACE

In Karnataka, as in other Indian States, the livelihoods of rural people are intertwined with farming pursuits. Thechallenges in agriculture are seriously threatening the livelihood of a large number of farmers as they have been practicing farming in contextual factors beyond their control. Climatic factors are the most important ones and have become much more significant in recent times due to rapid climate changes induced by intensive anthropogenic activities affecting our ecosystem in multiple ways. Climate change has become the reality, it is happening and efforts to evolve and demonstrate climate resilient technologies have become essential. Due to the already over stressed scenario of agrarian sector, the climate change is resulting in manifold increase in the complexities, pushing the rural mass to face more and more unpredictable situations. The rising temperatures and unpredictable rainfall patterns are going to test seriously the informed decisions farmers have to make in order to survive in farming and sustain their livelihood.

It is generally recognized that impacts of climate change shall not be uniform across the globe. It is said that impact of climate change is more severe in South Asia. Based on the analysis of meteorological data, it is predicted that in India, there will be upward trend in mean temperature, downward trend in relative humidity, annual rainfall and number of wet days in a year. Also, in general, phenomena like erratic monsoon, spread of tropical diseases, rise in sea levels, changes in availability of fresh water, frequent floods, droughts, heat waves, storms and hurricanes are predicted. Each one of these adverse situations are already being experienced in various parts of India and also at the global level. Decline in agricultural productivity of small and marginal farmers becoming more vulnerable is already witnessed.

In Karnataka, more than 60 per cent of the population live in rural areas and depend on agriculture and allied activities for their livelihood. Though the state has achieved significant progress in increasing the yield of many crops, there is tremendous pressure on the land resources due to the growing and competing demands of various land uses. This is reflected in the alarming rate of land degradation observed. Already more than 50 per cent of the area is affected by various forms of degradation. If this trend continues, the sustainability of the fragile ecosystem will be badly affected. The adverse effects of change in the climatic factors are putting additional stress on the land resources and the farmers dependent on this.

The natural resources (land, water and vegetation) of the state need adequate and constant care and management, backed by site-specific technological interventions and investments particularly by the government. Detailed database pertaining to the nature of

the land resources, their constraints, inherent potentials and suitability for various land based rural enterprises, crops and other uses is a prerequisite for preparing location-specific action plans, which are in tune with the inherent capability of the resources. Any effort to evolve climate resilient technologies has to be based on the baseline scientific database. Then only one can expect effective implementation of climate resilient technologies, monitor the progress, make essential review of the strategy, and finally evaluate the effectiveness of the implemented programs. The information available at present on the land resources of the state are of general nature and useful only for general purpose planning. Since the need of the hour is to have site-specific information suitable for farm level planning and detailed characterization and delineation of the existing land resources of an area into similar management units is the only option.

ICAR-NBSS&LUP, Regional Centre, Bangalore has taken up a project sponsored by the Karnataka Watershed Development Project-II, (Sujala-III), Government of Karnataka funded by the World Bank under Component -1 Land Resource Inventry. This study was taken up to demonstrate the utility of such a database in reviewing, monitoring and evaluating all the land based watershed development programs on a scientific footing. To meet the requirements of various land use planners at grassroots level, the present study on "Land Resource Inventory and Socio-Economic Status of Farm Households for Watershed Planning and Development of for Machinahalli-1 microwatershed in Shirahatti Taluk, Gadag District, Karnataka" for integrated development was taken up in collaboration with the State Agricutural Universities, IISC, KSRSAC, KSNDMC as Consortia partners. The project provides detailed land resource information at cadastral level (1:7920 scale) for all the plots and socio-economic status of farm households covering thirty per cent farmers randomely selected representing landed and landless class of farmers in the micowatershed. The project report with the accompanying maps for the microwatershed will provide required detailed database for evolving effective land use plan, alternative land use options and conservation plans for the planners, administrators, agricutural extention personnel, KVK officials, developmental departments and other land users to manage the land resources in a sustainable manner.

It is hoped that this database will be useful to the planners, administrators and developmental agencies working in the area in not only for formulating location specific developmental schemes but also for their effective monitoring at the village/watershed level.

Nagpur
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S.K. SINGH
Director, ICAR – NBSS&LUP, Nagpur

Contributors

Dr. Rajendra Hegde Principal Scientist, Head & Project Leader, Sujala-III Project ICAR-NBSS&LUP, Regional Centre, Bangalore	**Dr. S.K.Singh** Director, ICAR-NBSS&LUP Coordinator, Sujala-III Project Nagpur
Soil Survey, Mapping & Report Preparation	
Dr. K.V. Niranjana	Sh. R.S. Reddy
Dr. B.A. Dhanorkar	Sh. Venkata Giriyappa
	Dr. Gayathri, B.
	Smt. Chaitra, S.P.
	Sh. Nagendra, B.R.
	Dr. Savitha, H.R.
	Dr. Gopali Bardhan
	Sh. Somashekar T.N
Field Work	
Sh. C.Bache Gowda	Sh. Sandesh Shastri
Sh. Somashekar	Sh. Rajeev, G.S.
Sh. M. Jayaramaiah	Sh. Balasubramanyam, M.G.
Sh. Paramesha, K.	Sh. Vijaya Kumar
	Sh. Mayur Patil
	Sh. Kamalesh K. Avate
GIS Work	
Dr. S.Srinivas	Sh. A.G. Devendra Prasad
Sh. D.H.Venkatesh	Sh. Prakashanaik, M.K.
Smt.K.Sujatha	Sh. Abhijith Sastry, N.S.
Smt. K.V.Archana	Sh. Mahamad Ali, M.
Sh. N.Maddileti	Sh. Amar Suputhra, S.
	Sh. Avinash, K.N.
	Sh. Anudeep, Y.
	Sh. Sudip Kumar Suklabaidya
	Smt. K.Karunya Lakshmi
	Ms. Seema, K.V.
	Ms. A. Rajab Nisha
Laboratory Analysis	
Dr. K.M.Nair	Smt. Steffi Peter
Smt. Arti Koyal	Smt. Thara, V.R.
Smt. Parvathy, S.	Smt. Roopa, G.
	Ms. Shwetha, N.K.

	Smt. Ishrat Haji
	Ms. Pavana Kumari, P.
	Sh. Shanthaveeraswamy, H.M.
	Sh. Ramesh, K.
	Ms. Padmaja, S.
	Ms. Veena, M.
Soil & Water Conservation	
Sh. Sunil P. Maske	
Socio-Economic Analysis	
Dr. S.C. Ramesh Kumar	Sh. M. K. Prakashanaik
	Ms. Sowmya K.B
	Sh.Manjunath M
	Sh.Veerabhadraswamy R
	Sh.Lankesh RS
	Sh.Kalaveerachari R Kammar
	Sh.Pradyumma U
	Sh.Yogesha HN
	Sh.Vijay kumar lamani
	Sh.Arun N Kambar
	Sh.Vinay
	Sh.Basavaraj.Biradar
	Sh.Vinod R
	Sh.Praveenkumar P Achalkar
	Sh.Rajendra D
Watershed Development Department, GoK, Bangalore	
Sh. Rajeev Ranjan IFS Project Director & Commissioner, WDD	Dr. A. Natarajan NRM Consultant, Sujala-III Project
Dr. S.D. Pathak IFS Executive Director & Chief Conservator of Forests, WDD	

PART-A

LAND RESOURCE INVENTORY

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EXECUTIVE SUMMARY

The land resource inventory of Machinahalli-1microwatershed was conducted using village cadastral maps and IRS satellite imagery on 1:7920 scale. The false colour composites of IRS imagery were interpreted for physiography and these physiographic delineations were used as base for mapping soils. The soils were studied in several transects and a soil map was prepared with phases of soil series as mapping units. Random checks were made all over the area outside the transects to confirm and validate the soil map unit boundaries. The soil map shows the geographic distribution and extent, characteristics, classification, behavior and use potentials of the soils in the microwatershed.

The present study covers an area of 712 ha in Shirahatti taluk of Gadag district, Karnataka. The climate is semiarid and categorized as drought- prone with an average annual rainfall of 633 mm of which about 363 mm is received during south –west monsoon, 165 mm during north-east and the remaining 105 mm during the rest of the year. An area of about 81 per cent is covered by soils, 18 per cent by rock lands and 2 per cent by water bodies, settlements and others. The salient findings from the land resource inventory are summarized briefly below.

- *The soils belong to 11 soil series and 25 soil phases (management units) and 7 land use classes.*
- *The length of crop growing period is about 150 days starting from the 3rd week of June to 1st week of October.*
- *From the master soil map, several interpretative and thematic maps like land capability, soil depth, surface soil texture, soil gravelliness, available water capacity, soil slope and soil erosion were generated.*
- *Soil fertility status maps for macro and micronutrients were generated based on the surface soil samples collected at every 250 m grid interval.*
- *Land suitability for growing 23 major agricultural and horticultural crops were assessed and maps showing the degree of suitability along with constraints were generated.*
- *About 74 per cent area is suitable for agriculture, 7 per cent of the area is not suitable for agriculture and 17 per cent of the microwatershed area is occupied by rockout crops.*
- *About 50 per cent of the soils are shallow (25-50 cm) to moderately shallow (50-75 cm) and about 31 per cent are moderately deep (75-100 cm) to deep (100-150 cm) soils.*
- *About 34 per cent of the area has loamy soils at the surface and 47 per cent clayey soils at the surface.*
- *About 19 per cent of the area has non-gravelly soils, 45 per cent gravelly soils (15-35 % gravel) and 17 per cent very gravelly (35- 60% gravel) soils.*
- *About 46 per cent low (51-100 mm/m) to very low (<50mm/m), 12 per cent medium (101-150 mm/m) and 22 per cent very high (>200 mm/m) in available water capacity.*
- *About 63 per cent area has very gently sloping (1-3%), 16 per cent gently sloping (3-5%) and 1 per cent nearly level (0-1%) lands.*
- *An area of about 17 per cent has soils that are slightly eroded (e1), 40 per cent moderately eroded (e2) and 24 per cent are severely eroded.*

- *An area of about 18 per cent has soils that are moderately alkaline (pH 7.8 to 8.4) and 39 per cent strongly alkaline (pH 8.4 to >9.0) and 9 per cent slightly alkaline (pH 7.3-7.8).*
- *The Electrical Conductivity (EC) of the soils are dominantly <2 dsm^{-1} indicating that the soils are non-saline.*
- *About 34 per cent of the soils are medium (0.5-0.75%), low (<0.5%) in about 8 per cent and 38 per cent high (>0.75%) in organic carbon.*
- *An area of about 51 per cent low (<23 kg/ha) and 29 per cent medium (23-57 kg/ha) in available phosphorus.*
- *About 45 per cent medium (145-337 kg/ha) and 36 per cent high (>337 kg/ha) in available potassium.*
- *Available sulphur is medium (10-20 ppm) in about 45 per cent area and 36 per cent low (<10 ppm).*
- *Available boron is low (0.5 ppm) in about 42 per cent area, medium (0.5-1.0 ppm) in 38 per cent area and high (>1.0 ppm) in 1 per cent area.*
- *Available iron is deficient in about 75 per cent area and sufficient in 6 per cent area.*
- *Available manganese is sufficient in entire the microwatershed area.*
- *Available copper is sufficient in the entire microwatershed area..*
- *Available zinc is sufficient (>0.6 ppm) in 16 per cent and deficient (<0.6 ppm) in 65 per cent area of the microwatershed.*
- *The land suitability for 23 major crops grown in the microwatershed was assessed and the areas that are highly suitable (S1) and moderately suitable (S2) are given below. It is however to be noted that a given soil may be suitable for various crops but what specific crop to be grown may be decided by the farmer looking to his capacity to invest on various inputs, marketing infrastructure, market price and finally the demand and supply position.*

Land suitability for various crops in the microwatershed

Crop	*Suitability Area in ha (%)*			*Crop*	*Suitability Area in ha (%)*	
	Highly suitable (S1)	*Moderately suitable (S2)*			*Highly suitable (S1)*	*Moderately suitable (S2)*
Sorghum	*195(27)*	*130(18)*		*Sapota*	-	*16(2)*
Maize	-	*76(11)*		*Jackfruit*	-	*16(2)*
Cotton	*160(22)*	*165(23)*		*Jamun*	-	*16(2)*
Sunflower	*160(22)*	*61(8)*		*Musambi*	-	*176(25)*
Onion	-	*76(11)*		*Lime*	-	*176(25)*
Groundnut	-	*87(12)*		*Cashew*	-	*16(2)*
Chilli	-	*410(57)*		*Custard apple*	*160(22)*	*176(25)*
Sugarcane	-	-		*Amla*	*160(22)*	*159(22)*
Pomegranate	-	*264(37)*		*Tamarind*	-	*16(2)*
Tomato	-	*410 (57)*		*Marigold*	-	*324(45)*
Guava	-	*16 (2)*		*Chrysanthemum*	-	*324(45)*
Mango	-	*16 (2)*				

Apart from the individual crop suitability, a proposed crop plan has been prepared for the seven identified LUCs by considering only the highly and moderately suitable lands for different crops and cropping systems with food, fiber and horticulture crops.

-
- *Maintaining soil-health is vital to crop production and conserve soil and land resource base for maintaining ecological balance and to mitigate climate change. For this, several ameliorative measures have been suggested to these problematic soils like saline/alkali, highly eroded, sandy soils etc.,*
- *Soil and water conservation treatment plan has been prepared that would help in identifying the sites to be treated and also the type of structures required.*
- *As part of the greening programme, several tree species have been suggested to be planted in marginal and submarginal lands, field bunds and also in the hillocks, mounds and ridges that would help in supplementing the farm income, provide fodder and fuel and generate lot of biomass. This would help in maintaining an ecological balance and also contributes to mitigating the climate change.*

Chapter 1

INTRODUCTION

Soil being a vital natural resource on whose proper use depends the life supporting systems of a country and the socio-economic development of its people. Soils provide food, fodder, fibre and fuel for meeting the basic human and animal needs. With the ever increasing growth in human and animal population, the demand on soil for more food and fodder production is on the increase. The area available for agriculture is about 51 per cent of the total geographical area and more than 60 per cent of the people are still dependant on agriculture for their livelihood. However, the capacity of a soil to produce is limited and the limits to the production are set by its intrinsic characteristics, agroclimatic setting, and use and management. There is therefore, tremendous pressure on land and water resources, which is causing decline in soil-health and stagnation in productivity. The soils have been degrading at an estimated rate of one million hectares per year and ground water levels have been receding at an alarming rate resulting in decline in the ground water resource. Further, land degradation has emerged as a serious problem which has already affected about 38 lakh ha of cultivated area in the State. Soil erosion alone has degraded about 35 lakh ha. Almost all the uncultivated areas are facing various degrees of degradation, particularly soil erosion. Salinity and alkalinity has emerged as a major problem in more than 3.5 lakh ha in the irrigated areas of the State. Nutrient depletion and declining factor productivity is common in both rainfed and irrigated areas. The degradation is continuing at an alarming rate and there appears to be no systematic effort among the stakeholders to contain this process. In recent times, an aberration of weather due to climate change phenomenon has added another dimension leading to unpredictable situations to be tackled by the farmers.

In this critical juncture, the challenge before us is not only to increase the productivity per unit area which is steadily declining and showing a fatigue syndrome, but also to prevent or at least reduce the severity of degradation. If the situation is not reversed at the earliest, then the sustainability of the already fragile crop production system and the overall ecosystem will be badly affected in the state. Added to this, every year there is a significant diversion of farm lands and water resources for non-agricultural purposes. Thus, developing strategies to slow down the degradation process or reclaim the soils to normal condition and ensure sustainability of production system are the major issues today. This demands a systematic appraisal of our soil and land resources with respect to their extent, geographic distribution, characteristics, behaviour and use potential, which is very important for developing an effective land use and cropping systems for augmenting agricultural production on a sustainable basis.

The soil and land resource inventories made so far in Karnataka had limited utility because the surveys were of different types, scales and intensities carried out at different times with specific objectives. Hence, there is an urgent need to generate detailed site-

specific farm level database on various land resources for all the villages/watersheds in a time bound manner that would help to protect the valuable soil and land resources and also to stabilize farm production. Therefore, the land resource inventory required for farm level planning is the one which investigates all the parameters which are critical for productivity *viz.,* soils, site characteristics (slope, erosion, gravelliness and stoniness), climate, water, topography, geology, hydrology, vegetation, crops, land use pattern, animal population, socio-economic conditions, infrastructure, marketing facilities and various schemes and developmental works of the government etc. From the data collected at farm level, the specific problems and potentials of the area can be identified and highlighted, conservation measures required for the area can be planned on a scientific footing, suitability of the area for various uses can be worked out and finally viable and sustainable land use options suitable for each and every land holding can be prescribed.

The Land Resource Inventory is basically done for identifying potential and problem areas, developing sustainable land use plans, estimation of surface run off and water harvesting potential, preparation of soil and water conservation plans, land degradation/desertification etc. The Bureau is presently engaged in developing an LRI methodology using high resolution satellite remote sensing data and Digital Elevation Model (DEM) data to prepare Landscape Ecological Units (LEU) map representing agro-ecosystem as a whole. The LEU is preferred over landform as the base map for LRI. LEU is the assemblage of landform, slope and land use. An attempt has already been made to upscale the soil resource information from 1:250000 and 1:50000 scale to the LEU map in Goa and other states.

The land resource inventory aims to provide site specific database for Machinahalli-1 microwatershed in Shirahatti Taluk, Gadag District, Karnataka State for the Karnataka Watershed Development Department. The database was generated by using cadastral map of the village as a base along with high resolution IRS LISS IV and Cartosat-1 merged satellite imagery. Later, an attempt will be made to uplink this LRI data generated at 1:7920 scale under Sujala-III Project to the proposed Landscape Ecological Units (LEUs) map.

The study was organized and executed by the ICAR- National Bureau of Soil Survey and Land Use Planning, Regional Centre, Bangalore under Generation of Land Resource Inventory Data base Component-1 of the Sujala-III Project funded by the World Bank.

Chapter 2

GEOGRAPHICAL SETTING

2.1 Location and Extent

The Machinahalli-1 Microwatershed (Hadgali subwatershed) is located in the central part of northern Karnataka in Shirahatti Taluk, Gadag District, Karnataka State (Fig.2.1). It comprises parts of Majjur, Rantur, Nave Bavanur and Machinahalli villages. It lies between 15^0 06' and 15^0 08' North latitudes and 75^0 38' and 75^0 40' East longitudes and covers an area of 712 ha. It is about 60 km south of Gadag and is surrounded by Majjur village on north, Rantur village on the west, Nave Bavanur village on the south and Machinahalli village on the eastern side.

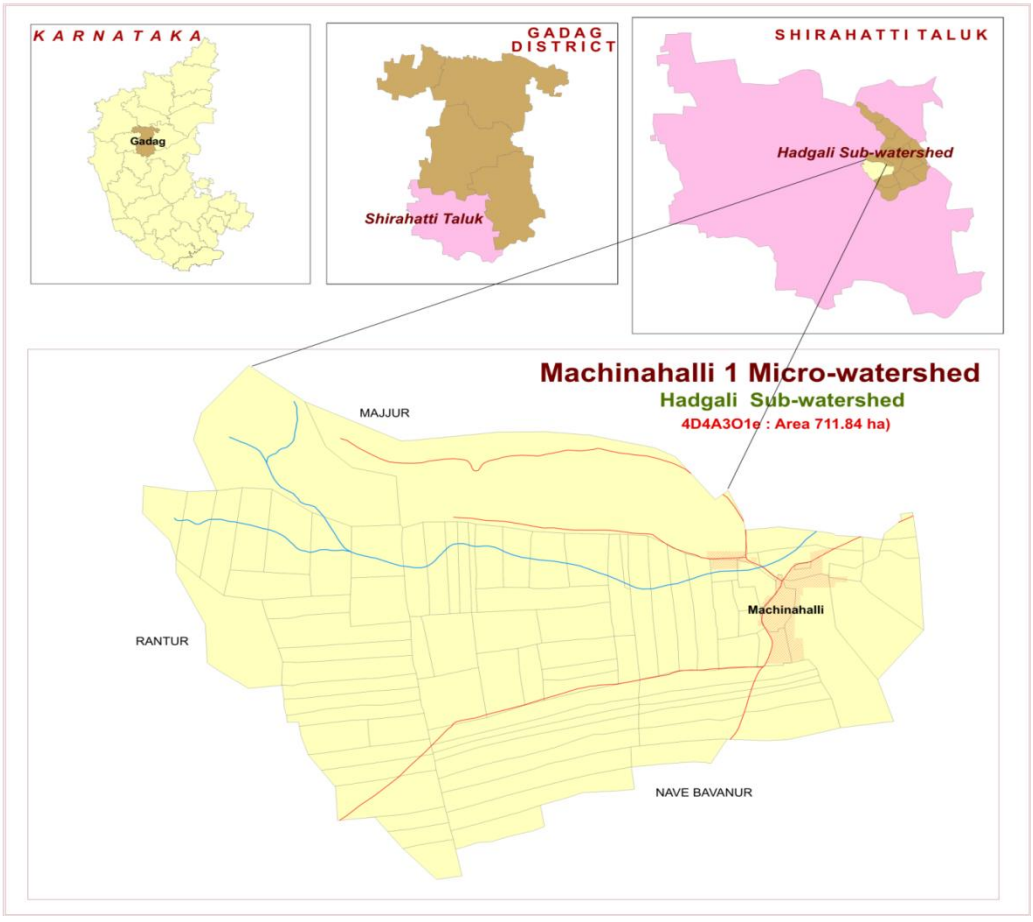


Fig.2.1 Location map of Machinahalli-1 Microwatershed

2.2 Geology

Major rock formations observed in the microwatershed are granite and granite gneiss and Gadag Schist (Fig.2.2a & 2.2b). Granite and granite gneiss are essentially pink to gray and rocks are coarse to medium grained. The gray granite gneisses are highly weathered, fractured and fissured upto a depth of about 10 m. Schists are found with thick coating of Banded Ferrugenous Quartzite and ridges have capping of Banded Ferrugenous Quartzite (BFQ), whereas side slopes near the streams are dominated by schist. They are fine grained

and show a distinct weathering pattern similar to that of basalt. Due to fine texture of Gadag schist, the soils formed from these rocks are mostly clayey in nature. The presence of iron rich banded ferrugenous quartzite is responsible for the dark red colour of the soils observed in the microwatershed.

Fig.2.2a Granite and granite gneiss rocks

Fig.2.2 b Gadag Schist rocks

2.3 Physiography

Physiographically, the area has been identified as Granite gneiss and Schist landscapes based on geology. The microwatershed area has been further divided into mounds/ridges, summits, side slopes and very gently sloping uplands based on slope and its relief features. The elevation ranges from 578 to 624 m. The mounds and ridges are mostly covered by rock outcrops.

2.4 Drainage

The area is drained by several small seasonal streams that join Dodd Halla along its course. Though, it is not a perennial one, during rainy season it carries large quantities of rain water. The microwatershed has only few small tanks which are not able to store the water flowing during the rainy season. Due to this, the ground water recharge is very much affected in the villages. This is reflected in the failure of many bore wells in the villages. If the available rain water is properly harnessed by constructing tanks and recharge structures at appropriate places in the villages, then the drinking and irrigation needs of the entire area can be easily met. The drainage network is dendritic to sub parallel.

2.5 Climate

The district falls under semiarid tract of the state and is categorized as drought-prone with average annual rainfall of 633 mm (Table 2.1). Maximum of 363 mm precipitation takes place during south–west monsoon period from June to September, north-east monsoon contributes about 165 mm and prevails from October to early December and the remaining 105 mm takes place during the rest of the year. The winter season is from December to February. During April and May, the temperatures reach up to 42°C and in December and January, the temperatures will go down to 16°C. Rainfall distribution is shown in Figure 2.3. The average Potential Evapo Transpiration (PET) is 137 mm and varies from a low of 109 mm in December to 182 mm in the month of May. The PET is always higher than precipitation in all the months except in the month of October. Generally, the Length of crop Growing Period (LGP) is 150 days and starts from 3rd week of June to third week of November.

Table 2.1 Mean Monthly Rainfall, PET, 1/2 PET at Shirahatti Taluk, Gadag District

Sl. No.	Months	Rainfall	PET	1/2 PET
1	January	0.80	122.20	61.10
2	February	1.50	131.40	65.70
3	March	15.20	172.00	86.00
4	April	30.10	178.80	89.40
5	May	57.60	182.00	91.00
6	June	87.10	146.20	73.10
7	July	79.90	130.80	65.40
8	August	87.80	130.80	65.40
9	September	108.70	123.20	61.60
10	October	121.00	113.10	56.55
11	November	36.00	112.70	56.35
12	December	7.80	108.70	54.35
TOTAL		**633.50**	**137.65**	

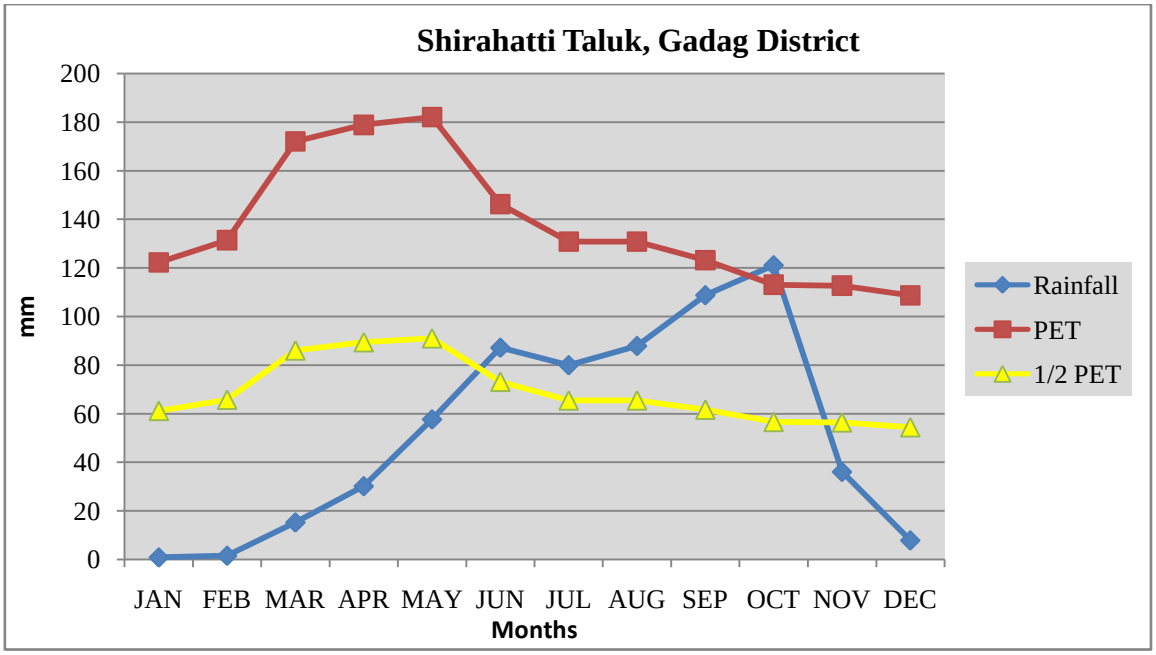


Fig. 2.3 Rainfall distribution in Shirahatti Taluk, Gadag District

2.6 Natural Vegetation

The natural vegetation is sparse comprising few tree species, shrubs and herbs. The mounds, ridges and boulders occupy very sizeable areas which are under thin to moderately thick forest vegetation. Still, there are some remnants of the past forest cover which can be seen in patches in some ridges and hillocks in the microwatershed.

Apart from the continuing deforestation, the presence of large population of goats, sheep and other cattle in the micowatershed is causing vegetative degradation of whatever little vegetation left in the area. The uncontrolled grazing has left no time for the regeneration of the vegetative cover. This leads to the accelerated rate of erosion on the hill slopes, resulting in the formation of deep gullies in the foot slopes and eventually resulting in the heavy siltation of few tanks and reservoirs in the microwatershed.

2.7 Land Utilization

About 77 per cent area (Table 2.2) in Shirahatti taluk is cultivated at present and about 14 per cent of the area is sown more than once. An area of about 17 per cent is currently barren. Forests occupy a small area of about 1.6 per cent and the tree cover is in a very poor state. Most of the mounds, ridges and bouldery areas have very poor vegetative cover. Major crops grown (Figure 2.4) in the area are sorghum, maize, cotton, safflower, sunflower, red gram, horse gram, onion, mulberry, sugarcane, bengal gram, pomegranate and groundnut. While carrying out land resource inventory, the land use/land cover particulars are collected from all the survey numbers and a current land use map of the microwatershed is prepared. The current land use map prepared shows the arable and non-arable lands, other land uses and different types of crops grown in the area. The current land use map of Machinahalli-1 Microwatershed is presented in Fig.2.5.

Simultaneously, enumeration of existing wells (bore wells and open wells) and other soil and water conservation structures in the microwatershed is made and their location in different survey numbers is marked on the cadastral map. Map showing the location of wells, soil conservation structures and other water bodies in Machinahalli-1 Microwatershed is given Fig.2.5.

Table 2.2 Land Utilization in Shirahatti Taluk

Sl.No.	Agricultural land use	Area (ha)	Per cent
1	Total cultivated area	85004	77.0
2	Cultivable wasteland	291	0.26
3	Pasture land	1054	1.0
4	Forest area	1749	1.6
5	Area sown more than once	15366	14.0
6	Current Barren	18302	16.7
7	Total geographical area	109751	

Fig. 2.4 Different crops and cropping systems in Machinahalli-1 Microwatershed

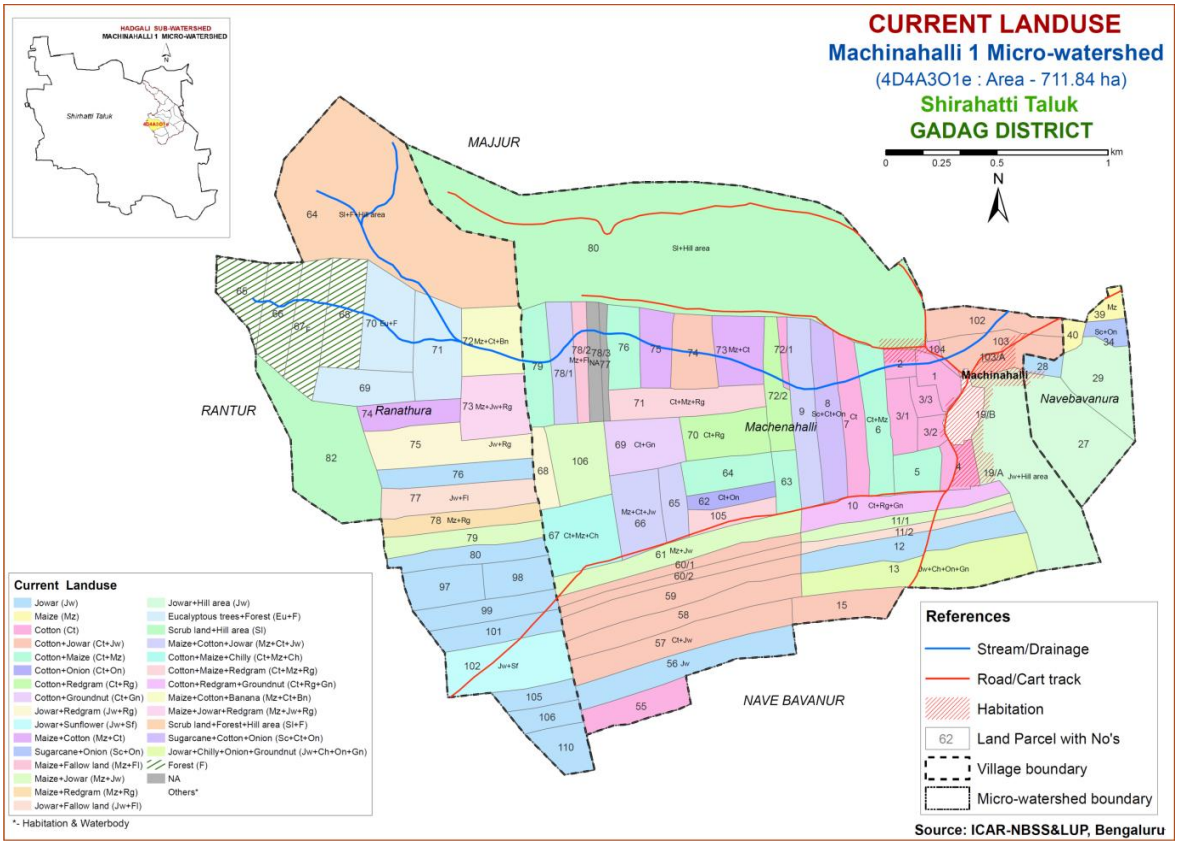


Fig.2.5 Current Land Use – Machinahalli-1 Microwatershed

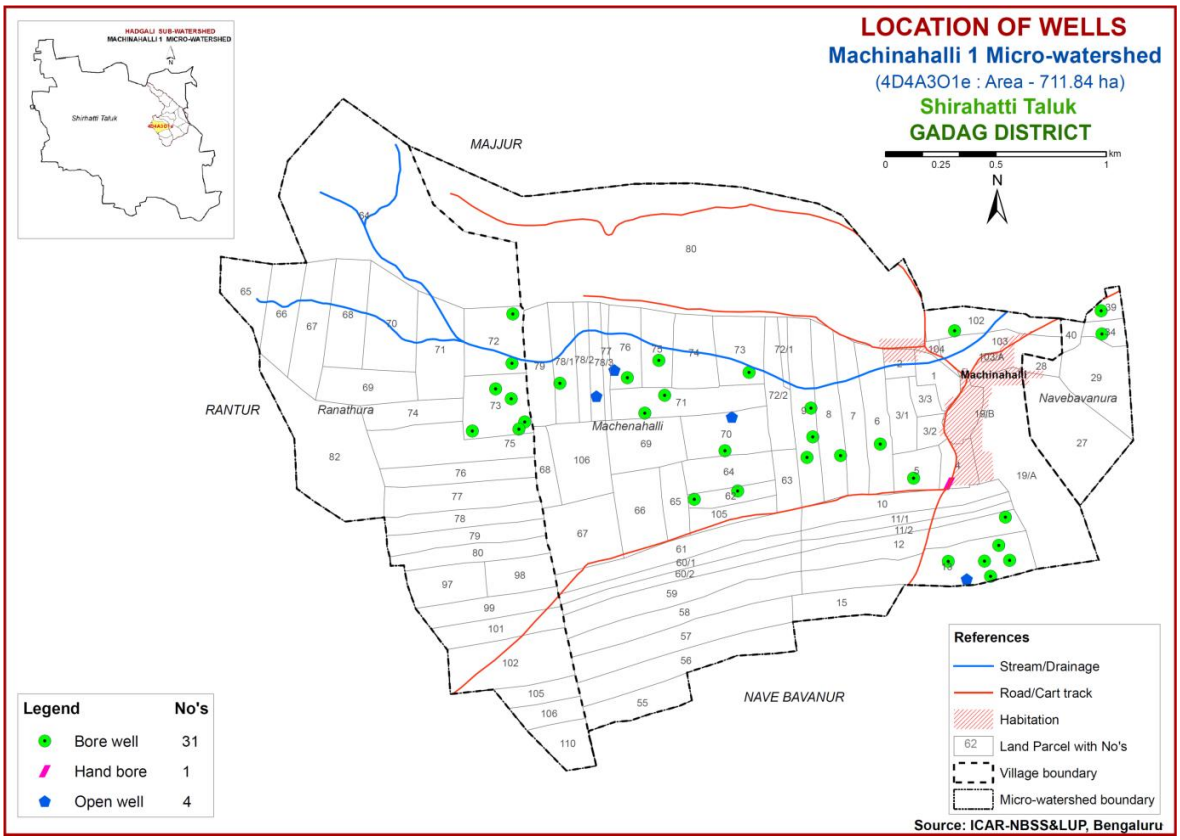


Fig.2.6 Location of Wells and conservation structures- Machinahalli-1 Microwatershed

Chapter 3

SURVEY METHODOLOGY

The purpose of land resource inventory is to delineate similar areas (soil series and phases), which respond or expected to respond similarly to a given level of management. This was achieved in Machinahalli-1 Microwatershed by the detailed study of all the soil characteristics (depth, texture, colour, structure, consistence, coarse fragments, porosity, soil reaction, soil horizons etc.) and site (slope, erosion, drainage, occurrence of rock fragments etc.) and followed by grouping of similar areas based on soil-site characteristics into homogeneous (management units) units and showing their extent and geographic distribution on the microwatershed cadastral map. The detailed soil survey at 1:7920 scale was carried out in 712 ha area. The methodology followed for carrying out land resource inventory was as per the guidelines given in Soil Survey Manual (IARI, 1971; Soil Survey Staff, 2006; Natarajan *et al.,* 2015) which is briefly described below.

3.1 Base Maps

The detailed survey of the land resources occurring in the microwatershed was carried out by using digitized cadastral map as a base. The cadastral map shows field boundaries with their survey numbers, location of tanks, streams and other permanent features of the area (Fig. 3.1). Apart from the cadastral map, remote sensing data products from Cartosat-1 and LISS IV merged at the scale of 1:7920 were used in conjunction with the cadastral map to identify the geology, landscapes, landforms and other surface features. The imagery helped in the identification and delineation of boundaries between hills, uplands and lowlands, water bodies, forest and vegetated areas, roads, habitations and other cultural features of the area (Fig.3.2).The cadastral map was overlaid on the satellite imagery (Fig.3.3) that helps to identify the parcel boundaries and other permanent features. Apart from cadastral maps and images, toposheets of the area (1:50,000 scale) were used for initial traversing, identification of geology, landscape, landforms, drainage features, present land use and also for selection of transects in the microwatershed.

3.2 Image Interpretation for Physiography

False Colour Composites (FCC) of Cartosat-I and LISS-IV merged satellite data covering the microwatershed area was visually interpreted using image interpretation elements and all the available collateral data with local knowledge. The delineated physiographic boundaries were transferred on to a cadastral map overlaid on satellite imagery. Physiographically, the area has been identified as granite gneiss and schist landscape and is divided into landforms such as ridges, mounds and uplands based on slope. They were further subdivided into physiographic/ image interpretation units based on image characteristics. The image interpretation legend for physiography is given below.

Image Interpretation Legend for Physiography

G- Granite gneiss landscape

G1			Hills/ Ridges/ Mounds
	G11		Summits
	G12		Side slopes
		G121	Side slopes with dark grey tones
G2			Uplands
	G21		Summits
	G22		Gently sloping uplands
		G221	Gently sloping uplands, yellowish green (eroded)
		G222	Gently sloping uplands, yellowish white (severely eroded)
	G23		Very gently sloping uplands
		G231	Very gently sloping uplands, yellowish green
		G232	Very gently sloping uplands, medium green and pink
		G233	Very gently sloping uplands, pink and green (scrub land)
		G234	Very gently sloping uplands, medium greenish grey
		G235	Very gently sloping uplands, yellowish white (eroded)
		G236	Very gently sloping uplands, dark green
		G237	Very gently sloping uplands, medium pink (coconut garden)
		G238	Very gently sloping uplands, pink and bluish white (eroded)

S-Schist landscape

S1		Uplands
	S11	Summits, greenish blue
	S12	Side slopes, greenish grey
S2		Very gently sloping uplands
	S21	Very gently sloping uplands, greenish grey
	S22	Very gently sloping uplands, medium grey
	S23	Very gently sloping uplands, dark grey
	S24	Very gently sloping uplands, light green (scrub lands)
	S25	Very gently sloping uplands, grey and pink
	S26	Very gently sloping uplands, whitish grey (eroded)

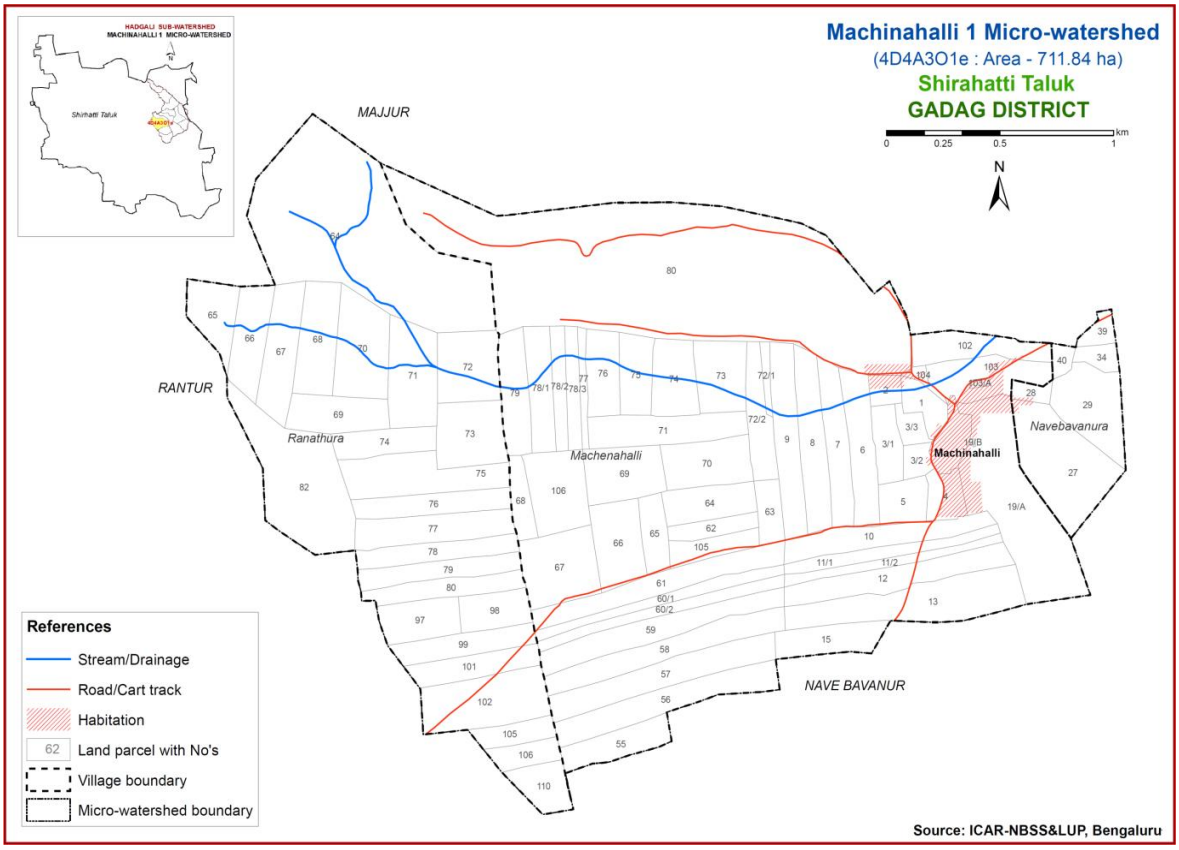


Fig 3.1 Scanned and Digitized Cadastral map of Machinahalli-1 Microwatershed

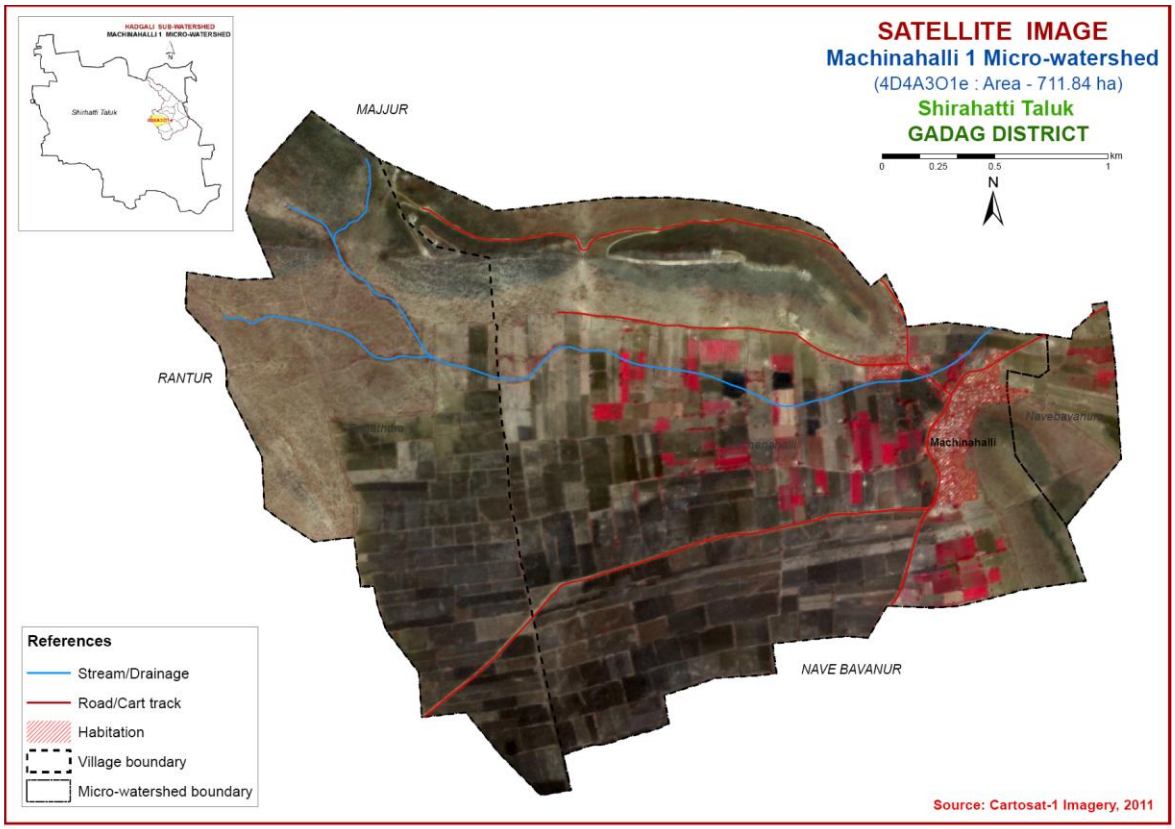


Fig.3.2 Satellite Image of Machinahalli-1 Microwatershed

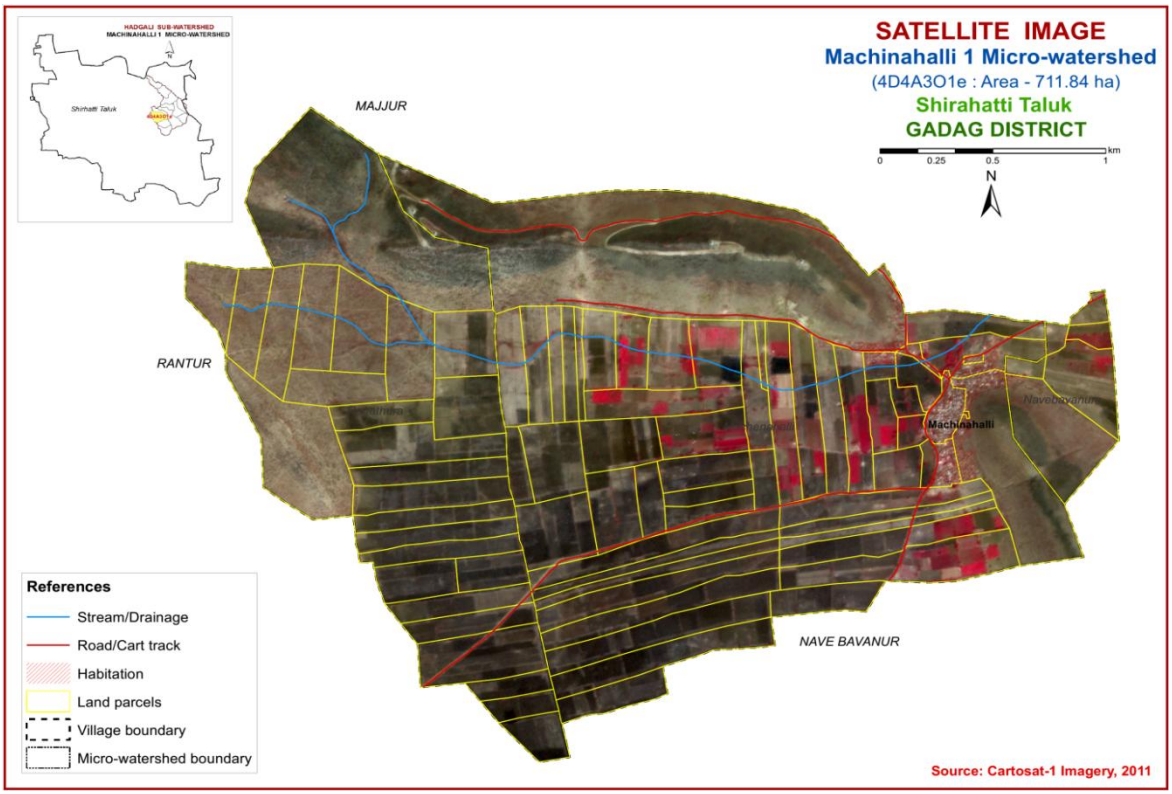


Fig.3.3 Cadastral map overlaid on IRS PAN+LISS IV merged imagery of Machinahalli-1 Microwatershed

3.3 Field Investigation

The field boundaries and survey numbers given on the cadastral sheet were located on the ground by following permanent features like roads, cart tracks, nallas, streams, tanks etc., and wherever changes were noticed, they were incorporated on the microwatershed cadastral map. Preliminary traverse of the microwatershed was carried out with the help of cadastral map, imagery and toposheets. While traversing, landforms and physiographic units identified were checked and preliminary soil legend was prepared by studying soils at few selected places. Then, intensive traversing of each physiographic unit like hills, ridges, uplands and valleys was carried out. Based on the variability observed on the surface, transects (Fig. 3.4) were selected across the slope covering all the landform units in the microwatershed (Natarajan and Dipak Sarkar, 2010).

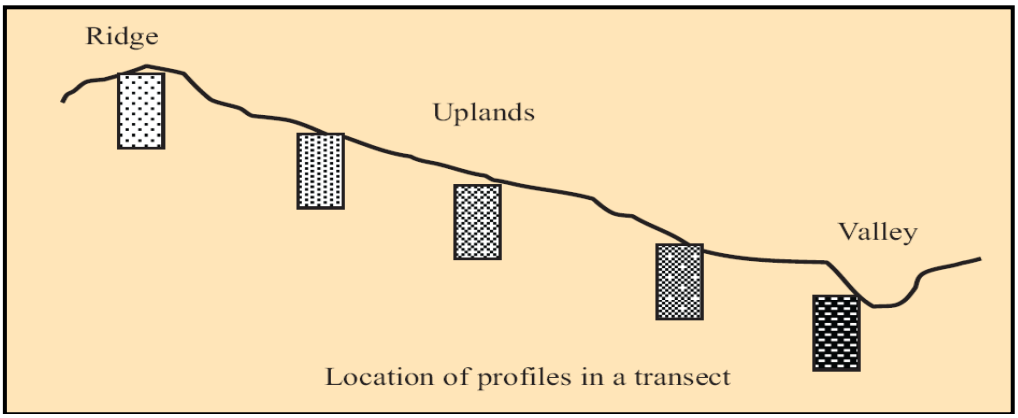


Fig: 3.4. Location of profiles in a transect

In the selected transect, soil profiles (Fig. 3.4) were located at closely spaced intervals to take care of any change in the land features like break in slope, erosion, gravel, stones etc. In the selected sites, profiles (vertical cut showing the soil layers from surface to the rock) were opened up to 200 cm or to the depth limited by rock or hard substratum and studied in detail for all their morphological and physical characteristics. The soil and site characteristics were recorded for all profile sites on a standard proforma as per the guidelines given in USDA Soil Survey Manual (Soil Survey Staff, 2012). Apart from the transect study, profiles were also studied at random, almost like in a grid pattern, outside the transect areas.

Based on the soil characteristics, the soils were grouped into different soil series. Soil series is the most homogeneous unit having similar horizons and properties and behaves similarly for a given level of management. Soil depth, texture, colour, kind of horizon and horizon sequence, amount and nature of gravel present, nature of substratum etc, were used as the major differentiating characteristics for identifying soil series occurring in the area. The differentiating characteristics used for identifying the soil series are given in Table 3.1. Based on the above characteristics, 11 soil series were identified in the Machinahalli-1 Microwatershed.

Table 3.1 Differentiating Characteristics used for identifying Soil Series

(Characteristics are of Series Control Section)

Soils of Granite Gneiss Landscape							
Sl. No	**Soil Series**	**Depth (cm)**	**Colour (moist)**	**Texture**	**Gravel (%)**	**Horizon sequence**	**Calcareousness**
1	Balapur (BPR)	100-150	2.5YR2.5/4,3/4	sc-c	>35	Ap-Bt-Cr	-
2	Kaggalipura (KGP)	25-50	2.5YR2.5/4	scl-sc	15-35	Ap-Bt-Cr	-
3	Kethanapura (KTP)	50-75	2.5YR3/4, 3/6	scl	15-35	Ap-Bt-Cr	-
4	Lakkur (LKR)	50-75	2.5YR3/4, 3/6	scl-sc	40-60	Ap-Bt-Bc-Cr	
5	Mukhadahalli (MKH)	50-75	5YR3/3,3/4,4/3, 5/4,6/6 2.5YR3/4	scl	>35	Ap-Bt-Cr	
6	Thammadahalli (TDH)	50-75	2.5YR2.5/4,3/6	sc-c	-	Ap-Bt-Cr	
Soils of Schist Landscape							
7	Attikatti Tanda (ATT)	50-75	10YR2/2,3/1,4/2,5/4, 7.5YR 2.5/1,3/2	c	-	Ap-Bw-Crk	-
8	Jelligeri (JLG)	75-100	10YR2/1,2/2,3/1 7.5 YR2.5/2,3/1, 3/2,3/3	c	-	Ap-Bw-Cr	-
9	Mahalingapur Tanda (MPT)	100-150	10YR2/2,3/1,3/2,3/3, 4/2, 7.5YR2.5/3, 3/2	c	-	Ap-Bw-Crk	-
10	Nabhapur Tanda (NPT)	25-50	7.5YR2.5/2,3/2,3/3 10YR3/1,3/2,2.5Y3/1	c	10-20	Ap-Bwk-Crk	e-es
11	Yelisirunj (YSJ)	25-50	7.5YR2/2,2.5/3,4/2 10YR3/1,3/2	cl-c	<15	Ap-Bw-Cr	-

3.4 Soil Mapping

The area under each soil series was further separated into soil phases and their boundaries delineated on the cadastral map based on the variations observed in the texture of the surface soil, slope, erosion, presence of gravel, stoniness etc. A soil phase is a subdivision of soil series based mostly on surface features that affect its use and management.

The soil mapping units are shown on the map (Fig.3.5) in the form of symbols. During the survey about 23 soil profile pits, few minipits and a few auger bores representing different landforms occurring in the microwatershed were studied. In addition to the profile study, spot observations in the form of minipits, road cuts, terrace cuts etc., were studied to validate the soil boundaries on the soil map.

The soil map shows the geographic distribution of 25 mapping units representing 11 soil series occurring in the microwatershed. The soil map unit (soil legend) description is presented in Table 3.2.

The soil phase map (management units) shows the distribution of 25 phases mapped in the microwatershed. Each mapping unit (soil phase) delineated on the map has similar soil and site characteristics. In other words, all the farms or survey numbers included in one soil phase will have similar management needs and have to be treated accordingly.

The 25 soil phases identified and mapped in the microwatershed were grouped into seven Land Use Classes (LUC's) for the purpose of preparing a Proposed Crop Plan for sustained development of the microwatershed. The database (soil phases) generated under LRI was utilized for identifying Land Use Classes (LUCs) based on the management needs. One or more than one soil site characteristic having influence on the management have been choosen for identification and delineation of LUCs. For Machinahalli-1 Microwatershed, five soil and site characteristics, namely soil depth, soil texture, slope, erosion and gravel content have been considered for defining LUCs. The Land Use Classes are expected to behave similarly for a given level of management.

3.5 Laboratory Characterization

Soil samples were collected from representative master profiles for laboratory characterization by following the methods outlined in the Laboratory Manual (Sarma *et al*, 1987). Surface soil samples collected in the year 2014 from farmer's fields (83 samples) for fertility status (major and micronutrients) at 250 m grid interval were analyzed in the laboratory (Katyal and Rattan, 2003). By linking the soil fertility data to the survey numbers through GIS, soil fertility maps using kriging method were generated using kriging method for the microwatershed.

Table 3.2 Soil map unit description of Machinahalli-1 Microwatershed

(Soil Legend)

Sl. No.	Soil Series	Soil Phases	Mapping Unit description	Area in ha (%)
SOILS OF GRANITE GNEISS LANDSCAPE				
	BPR	Balapur soils are deep (100-150 cm), well drained, have dark reddish brown to dark red gravelly sandy clay to clay soils occurring on very gently to gently sloping uplands under cultivation		**16.01 (2.25)**
1		BPRhC3g2	Sandy clay loam surface, slope 3-5%, severe erosion, very gravelly (35-60%)	16.01 (2.25)
	KGP	Kaggalipura soils are shallow (25 - 50 cm), well drained, have brown to dark reddish brown sandy clay loam to sandy clay soils occurring on very gently sloping uplands under cultivation		**155.07 (21.80)**
2		KGPfB2g2	Clay loam surface, slope 1-3%, moderate erosion, very gravelly (35-60%)	4.95 (0.70)
3		KGPfB3g1	Clay loam surface, slope 1-3%, severe erosion, gravelly (15-35%)	59.97 (8.43)
4		KGPfC3g2	Clay loam surface, slope 3-5%, severe erosion, very gravelly (35-60%)	22.12 (3.11)
5		KGPfC3g2R2St2	Clay loam surface, slope 3-5%, severe erosion, very gravelly (35-60%), fairly rocky (2-10%), very stony (0.1-3%)	47.84 (6.72)
6		KGPhB1g1	Sandy clay loam surface, slope 1-3%, slight erosion, gravelly (15-35%)	9.53 (1.34)
7		KGPiB2g2	Sandy clay surface, slope 1-3%, moderate erosion, very gravelly (35-60%)	10.66 (1.50)
	KTP	Kethanapura soils are moderately shallow (50-75 cm), well drained, have dark reddish brown gravelly sandy loam soils occurring on very gently to gently sloping uplands under cultivation		**43.51 (6.11)**
8		KTPhB1g1	Sandy clay loam surface, slope 1-3%, slight erosion, gravelly (15-35%)	18.87 (2.65)
9		KTPmC3g1	Clay surface, slope 3-5%, severe erosion, gravelly (15-35%)	24.64 (3.46)
	LKR	Lakkur soils are moderately shallow (50-75 cm), well drained, have reddish brown to dark red gravelly sandy clay loam to sandy clay red soils occurring on nearly level to gently and moderately sloping uplands under cultivation		**7.19 (1.01)**
10		LKRhC2g2	Sandy clay loam surface, slope 3-5%, moderate erosion, very gravelly (35-60%)	7.19 (1.01)
	MKH	Mukhadahalli soils are moderately shallow (50-75 cm), well drained, have dark brown to reddish brown gravelly sandy clay loam soils occurring on very gently to gently sloping uplands under cultivation		**3.47 (0.49)**
11		MKHmB2g1	Clay surface, slope 1-3%, moderate erosion, gravelly (15-35 %)	3.47 (0.49)
	TDH	Thammadahalli soils are moderately shallow (50 – 75 cm),		**16.20**

		well drained, have brown to very dark brown and dark reddish brown sandy loam to clay loam soils occurring on nearly level to gently sloping uplands under cultivation		**(2.28)**
12		TDHfB2g1	Clay loam surface, slope 1-3%, moderate erosion, gravelly (15-35 %)	16.20 (2.28)
SOILS OF SCHIST LANDSCAPE				
	ATT	Attikatti soils are moderately shallow (50-75 cm), well drained, have dark brown to very dark brown clayey soils occurring on very gently sloping uplands under cultivation		**44.59 (6.27)**
13		ATTmB2	Clay surface, slope 1-3%, moderate erosion	15.28 (2.15)
14		ATTmB2g1	Clay surface, slope 1-3%, moderate erosion, gravelly (15-35%)	29.31 (4.12)
	JLG	Jelligeri soils are moderately deep (75-100 cm), moderately well drained, very dark brown to dark brown and black cracking clay soils occurring on very gently sloping uplands under cultivation		**44.23 (6.22)**
15		JLGmB2	Clay surface, slope 1-3%, moderate erosion	16.69 (2.35)
16		JLGmB1g1	Clay surface, slope 1-3%, slight erosion, gravelly (15-35%)	4.54 (0.64)
17		JLGmB2g1	Clay surface, slope 1-3%, moderate erosion, gravelly (15-35%)	13.69 (1.92)
18		JLGmB2g2	Clay surface, slope 1-3%, moderate erosion, very gravelly (35-60%)	9.31 (1.31)
	MPT	Mahalingapur Tanda soils are deep (100-150 cm), moderately well drained, have very dark brown to very dark greyish brown cracking clay soils occurring on very gently sloping uplands under cultivation		**159.63 (22.42)**
19		MPTmA2g1	Clay surface, slope 0-1%, moderate erosion, gravelly (15-35%)	8.93 (1.25)
20		MPTmB1g1	Clay surface, slope 1-3%, slight erosion, gravelly (15-35%)	85.36 (11.99)
21		MPTmB2	Clay surface, slope 1-3%, moderate erosion	65.34 (9.18)
	NPT	Nabhapur Tanda soils are shallow (25-50 cm), well drained, have very dark brown to very dark gray calcareous clay soils occurring on very gently sloping uplands under cultivation		**39.51 (5.55)**
22		NPTfB2g1	Clay loam surface, slope 1-3%, moderate erosion, gravelly (15-35%)	39.51 (5.55)
	YSJ	Yelisirunj soils are shallow (25-50 cm), well drained, have very dark brown to very dark greyish brown clay soils occurring on very gently sloping uplands under cultivation		**45.38 (6.38)**
23		YSJmB2	Clay surface, slope 1-3%, moderate erosion	39.28 (5.52)
24		YSJmB2g1	Clay surface, slope 1-3 %, moderate erosion, gravelly (15-35 %)	6.10 (0.86)
25	Rock outcrops	Rock lands, rocky and bouldery		123.62 (17.37)
26		Habitation		13.46 (1.89)

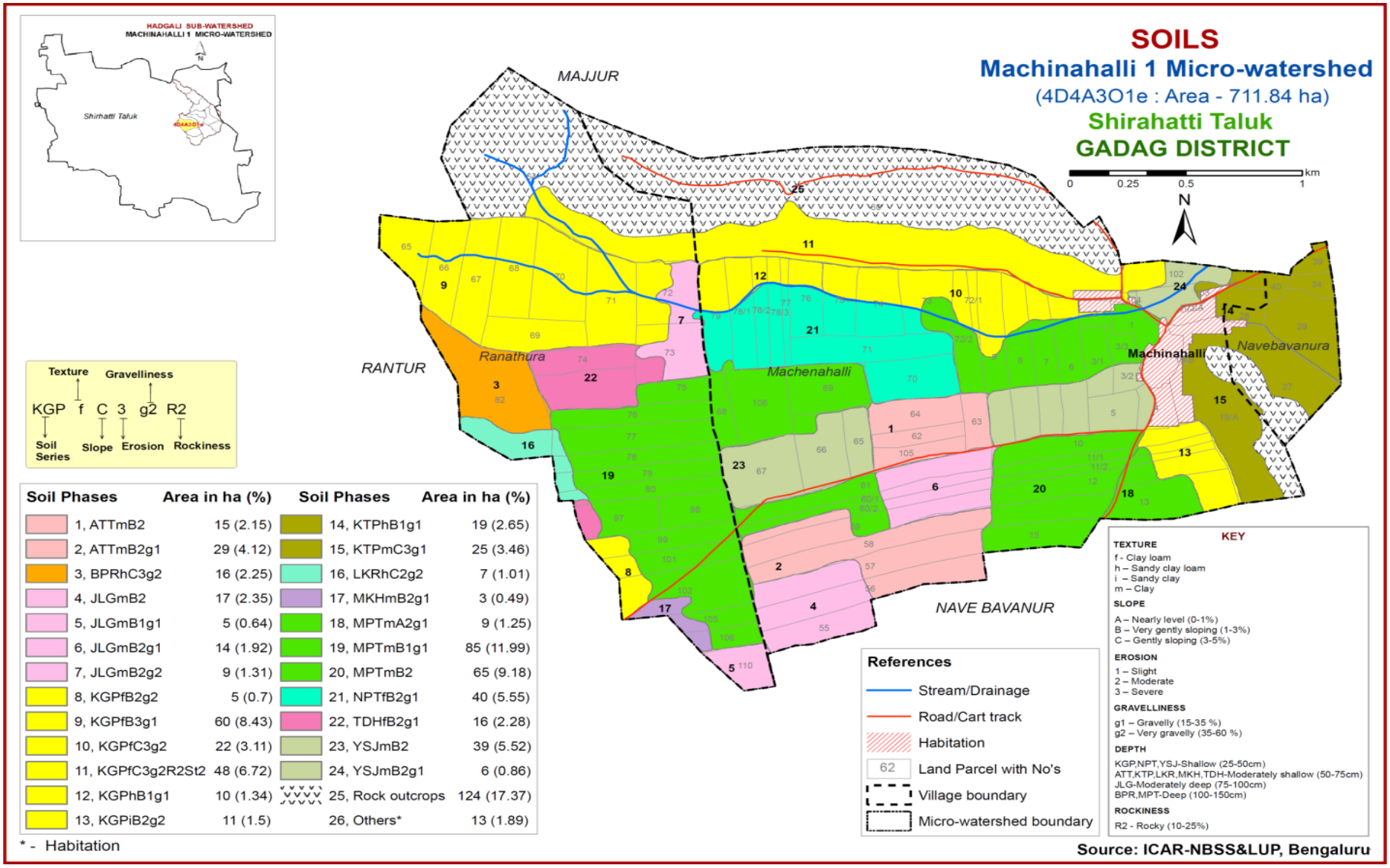


Fig 3.5 Soil Phase or Management Units- Machinahalli-1 Microwatershed

Chapter 4

THE SOILS

Detailed information pertaining to the nature, extent and distribution of different kinds of soils occurring in Machinahalli-1 Microwatershed is provided in this chapter. The microwatershed area has been identified as Granite Gneiss and Schist Landscapes based on geology. In all, eleven soil series are identified, sixin granite gneiss and five in Schist landscapes. Soil formation is the result of the combined effect of environmental and terrain factors that are reflected in soil morphology. The soil formation is dominantly influenced by the parent material, climate and relief.

A brief description of each of the eleven soil series identified followed by 25 soil phases (management units) mapped under each series (Fig. 3.5) are furnished below. The soils in any one map unit differ from place to place in their depth, texture, slope, gravelliness, erosion or any other site characteristic that affect management. The soil phase map can be used for identifying the suitability of areas for growing specific crops or for other alternative uses and also for deciding the type of conservation structures needed. The detailed information on soil and site-characteristics like soil depth, surface soil texture, slope, erosion, gravelliness, AWC, LCC etc, with respect to each of the soil phase identified is given village/survey number wise for the microwatershed in Appendix-I.

4.1 Soils of Granite Gneiss Landscape

In this landscape, six soil series are identified and mapped. Of these, Kaggalipura (KGP) soil series occupies maximum area of about 155 ha (22%) and Kethanapura (KTP) soil series occupies about 43 ha (6%) area. The mapping unit description (Soil Legend) of the phases identified and mapped under each series given in Table 3.2.

4.1.1 Balapur (BPR) Series: Balapur soils are deep (100-150 cm), well drained, have dark reddish brown to dark red gravelly sandy clay to clay soils. They are developed from weathered granite gneiss and occur on very gently to gently sloping uplands. The Balapur series has been tentatively classified as a member of the clayey-skeletal, mixed, isohyperthermic family of Rhodic Paleustalfs.

The thickness of the solum ranges from 102 to 147 cm. The thickness of A horizon ranges from 12 to 17 cm. Its colour is in 5 YR and 2.5 YR hue with value and chroma 3 to 4. The texture ranges from loamy sand to sandy clay with 15 to 50 per cent gravel. The thickness of B horizon ranges from 90 to 132 cm. Its colour is in 2.5 YR hue with value 2.5 to 3 and chroma 4 to 6. Texture is sandy clay to clay with 35 to 50 per cent gravel. The available water capacity is medium (100-150 mm/m). Only one phase was identified and mapped.

Landscape and soil profile characteristics of Balapur (BPR) Series

4.1.2 Kaggalipura (KGP) Series: Kaggalipura soils are shallow (25-50 cm), well drained, have brown to dark reddish brown sandy clay loam to sandy clay soils. They have developed from granite gneiss and occur on very gently sloping uplands. The Kaggalipura series has been tentatively classified as a member of the fine, mixed, isohyperthermic family of Typic Rhodustalfs.

The thickness of the solum ranges from 28 to 50 cm. The thickness of A horizon ranges from 12 to 17 cm. Its colour is in 7.5 YR, 5YR and 2.5 YR hue with value 2.5 to 4 and chroma 2 to 6. The texture varies from sandy clay loam to sandy clay with 10 to 25 per cent gravel. The thickness of B horizon ranges from 28 to 35 cm. Its colour is in 2.5 YR hue with value 2.5 and chroma 4. Its texture is sandy clay with gravel content of 15 to 35 per cent. The available water capacity is low (50-100 mm/m). Six phases were identified and mapped.

Landscape and soil profile characteristics of Kaggalipura (KGP) Series

4.1.3 Kethanapura (KTP) Series: Kethanapura soils are moderately shallow (50-75cm), well drained, have dark reddish brown gravelly sandy loam soils. They are developed from weathered granite gneiss and occur on very gently to gently sloping uplands. The Kethanapura series has been tentatively classified as a member of the fine-loamy, mixed, isohyperthermic family of Typic Rhodustalfs.

The thickness of the solum ranges from 53 to 72 cm. The thickness of A horizon ranges from 11 to 16 cm. Its colour is in 5YR and 2.5 YR hue with value 3 to 4 and chroma 3 to 6. The texture varies from loamy sand to sandy clay loam with 15 to 40 per cent gravel. The thickness of B horizon varies from 41 to 56 cm. Its colour is in 2.5 YR hue with value 2.5 to 3 and chroma 4 to 6. Texture is dominantly sandy clay loam with 15 to 35 per cent gravel. The available water capacity is medium (100-150 mm/m). Two phases were identified and mapped

Landscape and soil profile characteristics of Kethanapura (KTP) Series

4.1.4 Lakkur (LKR) Series: Lakkur soils are moderately shallow (50-75cm), well drained, have reddish brown to dark red gravelly sandy clay loam to sandy clay red soils. They have developed from granite gneiss and occur on nearly level to very gently and gently sloping uplands. The Lakkur series has been tentatively classified as a member of the clayey-skeletal, mixed, isohyperthermic family of Typic Rhodustalfs.

The thickness of the solum ranges from 51 to 74 cm. The thickness of A horizon ranges from 12 to 18 cm. Its colour is in 5YR and 2.5 YR hue with value 3 to 4 and chroma 4 to 6. The texture varies from loamy sand to sandy clay loam with 15 to 50 per cent gravel. The thickness of B horizon ranges from 39 to 58 cm. Its colour is in 2.5 YR hue with value 2.5 to 3 and chroma 4 to 6. Texture varies from sandy clay loam to sandy clay with 40 to 60 per cent gravel. The available water capacity is low (50-100 mm/m). Only one phase was identified and mapped.

Landscape and soil profile characteristics of Lakkur (LKR) Series

4.1.5 Mukhadahalli (MKH) Series: Mukhadahalli soils are moderately shallow (50-75 cm), well drained, have dark brown to reddish brown gravelly sandy clay loam soils. They are developed from weathered granite gneiss and occur on very gently to gently sloping uplands. The Mukhadahalli series has been tentatively classified as a member of the loamy-skeletal, mixed, isohyperthermic family of Typic Haplustalfs.

The thickness of the solum ranges from 51 to 72 cm. The thickness of A horizon ranges from 12 to 17 cm. Its colour is in 5 YR and 7.5 YR hue with value 3 to 4 and chroma 2 to 4. The texture varies from loamy sand to sandy loam with 20 to 45 per cent gravel. The thickness of B horizon ranges from 40 to 63 cm. Its colour is in 2.5 YR and 5 YR hue with value and chroma 3 to 6. Texture is sandy clay loam to sandy clay with 35 to 50 per cent gravel. The available water capacity is low (50-100 mm/m). Only one phase was identified and mapped.

Landscape and soil profile characteristics of Mukhadahalli (MKH) Series

4.1.6 Thammadahalli (TDH) Series: Thammadahalli soils are moderately shallow (50-75cm), well drained, have brown to very dark brown and dark reddish brown sandy loam to clay loam soils. They have developed from granite gneiss and occur on nearly level to gently sloping uplands. The Thammadahalli series has been tentatively classified as a member of the fine, mixed, isohyperthermic family of Rhodic Paleustalfs.

The thickness of the solum ranges from 54 to 75 cm. The thickness of A horizon ranges from 11 to 19 cm. Its colour is in 7.5 YR, 5YR and 2.5 YR hue with value 2.5 to 4 and chroma 2 to 6. The texture varies from sandy loam to clay loam with 10 to 20 per cent gravel. The thickness of B horizon ranges from 43 to 60 cm. Its colour is in 2.5 YR hue with value 3 and chroma 4 to 6. Its texture is sandy clay loam to sandy clay. The available water capacity is medium (100-150 mm/m). Only one phase was identified and mapped.

Landscape and soil profile characteristics of Thammadahalli (TDH) Series

4.2 Soils of Schist Landscape

In this landscape, five soil series are identified and mapped. Of these, Mahalingapur Tanda (MPT) soil series occupies maximum area of about 160 ha (22%) and Yelisirunj (YSJ) soil series occupies about 45 ha (6%). The mapping unit description (Soil Legend) of the phases identified and mapped under each series is given in Table 3.2.

4.2.1 Attikatti Tanda (ATT) Series: Attikatti Tanda soils are moderately shallow (50-75 cm), well drained, have dark brown to very dark brown clayey soils. They are developed from schist and occur on very gently sloping uplands. The Attikatti Tanda series has been tentatively classified as a member of the very fine, smectitic, isohyperthermic family of Vertic Haplustepts.

The thickness of the solum ranges from 51-73 cm. Thickness of A horizon ranges from 12 to 18 cm. Its colour is in hue 10 YR and 7.5 YR with value 2 to 3 and chroma 1to 3. The texture is dominantly clay. The thickness of the B horizon ranges from 36 to 52 cm. Its color is in hue 7.5 Yr, 10 YR with value 2.5 to 5 and chroma 1 to 4. Texture is dominantly clay. The available water capacity is low (50-100 mm/m). Two phases were identified and mapped.

Landscape and soil profile characteristics of Attikatti Tanda (ATT) Series

4.2.2 Jelligeri (JLG) Series: Jelligeri soils are moderately deep (75-100 cm), moderately well drained, very dark brown to dark brown and black cracking clay soils. They have developed from schist and occur on very gently sloping uplands. The Jelligeri series has been tentatively classified as a member of the fine, smectitic, isohyperthermic family of Vertic Haplustepts.

The thickness of the solum ranges from 78 to 98 cm. The thickness of A horizon ranges from 15 to 20 cm. Its colour is in hue 10 YR and 7.5 YR with value 2 to 3 and chroma 1 to 3. Its texture is dominantly clay. The thickness of B horizon ranges from 63 to 78 cm. Its colour is in hue 10 YR and 7.5 YR with value 2 to 3 and chroma 1 to 3. Its texture is dominantly clay. The available water capacity is high (150-200 mm/m). Four phases were identified and mapped.

Landscape and soil profile characteristics of Jelligeri (JLG) Series

4.2.3 Mahalingapur Tanda (MPT) Series: Mahalingapur Tanda soils are deep (100-150 cm), moderately well drained, very dark brown to very dark grayish brown cracking clay soils. They have developed from schist and occur on very gently sloping uplands. The Mahalingapur Tanda series has been tentatively classified as a member of the fine, smectitic, isohyperthermic family of Typic Haplusterts.

The thickness of the solum ranges from 117 to 145 cm. The thickness of A horizon ranges from 13 to 21 cm. Its colour is in hue 10 YR and 7.5 YR with value 2 to 4 and chroma 1 to 3. Its texture is dominantly clay. The thickness of B horizon ranges from 104 to 124 cm. Its colour is in hue 10 YR and 7.5 YR with value 2 to 4 and chroma 1 to 3. Its texture is dominantly clay. The available water capacity is very high (200-250 mm/m). The three phases were identified and mapped.

Landscape and soil profile characteristics of Mahalingapur Tanda (MPT) Series

4.2.4 Nabhapur Tanda (NPT) Series: Nabhapur Tanda soils are shallow (25-50 cm), well drained, have very dark brown to very dark gray, calcareous clay soils. They have developed from schist and occur on very gently sloping uplands.The Nabhapur Tanda series has been tentatively classified as a member of the fine, smectitic (calcareous), isohyperthermic family of Typic Haplustepts.

The thickness of the solum ranges from 30 to 50 cm. The thickness of A horizon ranges from 15 to 18 cm. Its colour is in 7.5 YR and 10 YR hue with value 2.5 to 3 and chroma 2 to 3. The texture varies from sandy clay to clay with 10 to 20 per cent gravel. The thickness of B horizon ranges from 15 to 35 cm. Its colour is in 2.5 Y, 10 YR and 7.5 YR hue with value 2.5 to 3 and chroma 1 to 3. Its texture is clay with gravel content of 10 to 20 per cent. The available water capacity is medium (100-150 mm/m). Only one phase was identified and mapped.

Landscape and soil profile characteristics of Nabhapur Tanda (NPT) Series

4.2.5 Yelisirunj (YSJ) Series: Yelisirunj soils are shallow (25-50 cm), well drained, have very dark brown to very dark grayish brown clay soils. They have developed from schist and occur on very gently sloping uplands. The Yelisirunj series has been tentatively classified as a member of the fine, smectitic, isohyperthermic family of Typic Haplustepts.

The thickness of the solum ranges from 28 to 49 cm. The thickness of A horizon ranges from 12 to 20 cm. Its colour is in hue 7.5 YR and 10 YR with value 2 to 4 and chroma 1 to 3. Texture is dominantly clay loam. The thickness of B horizon ranges from 16 to 29 cm. Its colour is in hue 7.5 YR and 10 YR with value 2 to 4 and chroma 1 to 3. Its texture is dominantly clay. The available water capacity is low (50-100 mm/m). Two phases were identified and mapped.

Landscape and soil profile characteristics of Yelisirunj (YSJ) Series

Chapter 5

INTERPRETATION FOR LAND RESOURCE MANAGEMENT

The most important soil and site characteristics that affect the land use and conservation needs of an area are land capability, soil depth, soil texture, coarse fragments, available water capacity, soil slope, soil erosion, soil reaction etc. These are interpreted from the data base generated through land resource inventory and several thematic maps are generated. These would help in identifying the areas suitable for growing crops and, soil and water conservation measures and structures needed thus helping to maintain good soil health for sustained crop production. The various thematic maps generated are described below.

5.1 Land Capability Classification

Land Capability Classification is an interpretative grouping of soil map units (soil phases) mainly based on inherent soil characteristics, external land features and environmental factors that limit the use of land for agriculture, pasture, forestry, or other uses on a sustained basis (IARI, 1971). The land and soil characteristics used to group the land resources in an area into various land capability classes, subclasses and units are

Soil characteristics: Depth, texture, gravel content, calcareousness.

Land characteristics: Slope, erosion, drainage, rock outcrops.

Climate: Total rainfall and its distribution, and length of crop growing period.

The land capability classification system is divided into land capability classes, subclasses and units based on the level of information available. Eight land capability classes are recognized. They are

Class I: They are very good lands that have no limitations or very few limitations that restrict their use.

Class II: They are good lands that have minor limitations and require moderate conservation practices.

Class III: They are moderately good lands that have severe limitations that reduce the choice of crops or that require special conservation practices.

Class IV: They are fairly good lands that have very severe limitations that reduce the choice of crops or that require very careful management.

Class V: Soils in these lands are not likely to erode, but have other limitations like wetness that are impractical to remove and as such not suitable for agriculture, but suitable for pasture or forestry with minor limitations.

Class VI: The lands have severe limitations that make them generally unsuitable for cultivation, but suitable for pasture or forestry with moderate limitations.

Class VII: The lands have very severe limitations that make them unsuitable for cultivation, but suitable for pasture or forestry with major limitations.

Class VIII: Soil and other miscellaneous areas (rock lands) that have very severe limitations that nearly preclude their use for any crop production, but suitable for wildlife, recreation and wind mills.

The land capability subclasses are recognised based on the dominant limitations observed within a given land capability class. The subclasses are designated by adding a lower case letter like 'e', 'w', 's', or 'c' to the class numeral. The subclass "e" indicates that the main hazard is risk of erosion, "w" indicates drainage or wetness as a limitation for plant growth, "s" indicates shallow soil depth, coarse or heavy textures, calcareousness, salinity/alkalinity or gravelliness and "c" indicates limitation due to climate.

The land capability subclasses have been further subdivided into land capability units based on the kinds of limitations present in each subclass. Ten land capability units are used in grouping the soil map units. They are stony or rocky (0), erosion hazard (slope, erosion) (1), coarse texture (sand, loamy sand, sandy loam) (2), fine texture (cracking clay, silty clay) (3), slowly permeable subsoil (4), coarse underlying material (5), salinity/alkali (6), stagnation, overflow, high ground water table (7), soil depth (8) and fertility problems (9). The capability units thus identified have similar soil and land characteristics that respond similarly to a given level of management. The soils of the microwatershed have been classified upto land capability subclass level.

The 25 soil map units identified in the Machinahalli-1 microwatershed are grouped under five land capability Classes and six land capability subclasses. An area of about 527 ha (74 %) in the microwatershed is suitable for agriculture and 26% is not suitable for agriculture (Fig. 5.1).

Good cultivable lands (Class II) cover very small area of about 35 ha (5%) and are distributed in the central and eastern part of the micowatershed with minor problems of soil. Moderately good cultivable lands (Class III) cover major area of about 299 ha (42%) and are distributed in the western, southern, central and eastern part of the microwatershed with moderate problems of soil and erosion. The fairly good cultivable lands (Class IV) cover an area of about 192 ha (27%) and occur in the northwestern, northeastern, central and small patches in the southeastern and southwestern part of the microwatershed. They have severe limitations of erosion and soil. The class VI lands cover about 48 ha (7%) that have severe limitations that make them not suitable for agriculture, but well suited for forestery, pasture etc. Soil and other miscellaneous areas (Class VIII) cover about 124 ha (17%) that have very severe limitations that preclude them for any crop productivity, but well suited for wildlife, recreation and installation of wind mills.

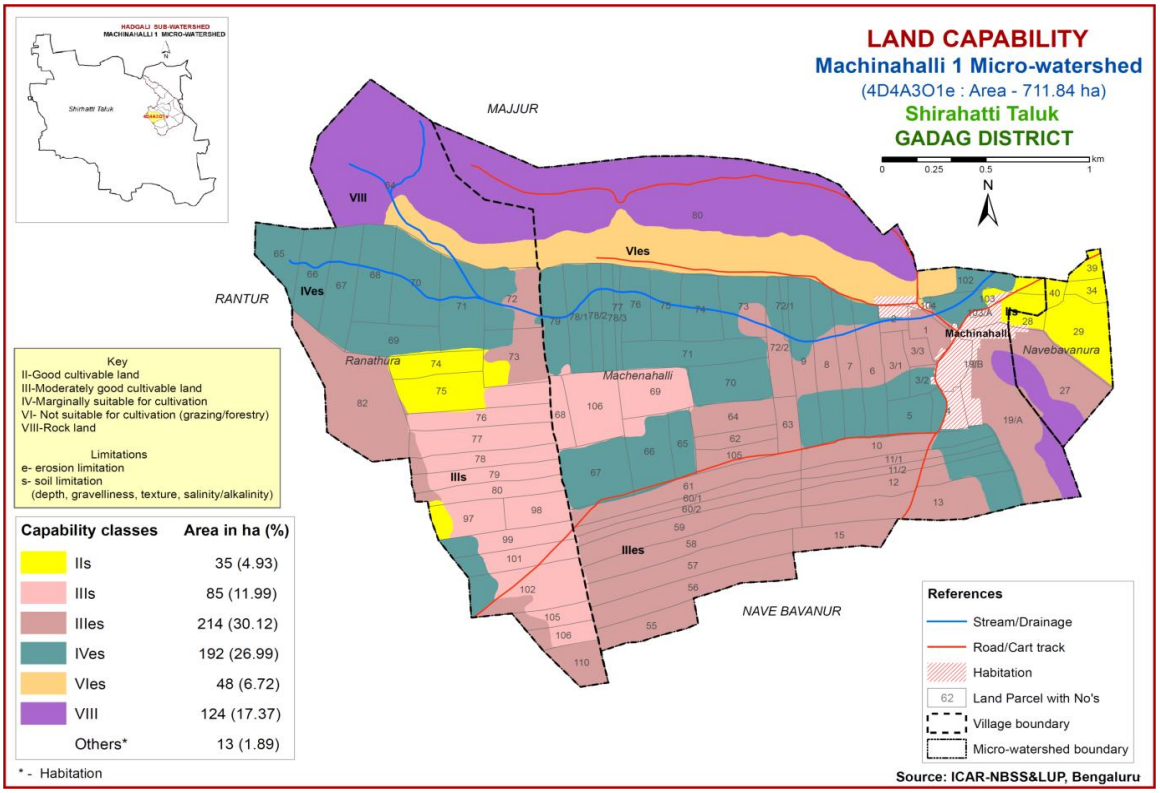


Fig. 5.1 Land Capability map of Machinahalli-1 Microwatershed

5.2 Soil Depth

Soil depth refers to the depth of the soil occurring above the parent material or hard rock. The depth of the soil determines the effective rooting depth for plants and in accordance with soil texture, mineralogy and gravel content, the capacity of the soil column to hold water and nutrient availability. Soil depth is one of the most important soil characteristic that is used in differentiating soils into different soil series. The soil depth classes used in identifying soils in the field are very shallow (<25 cm), shallow (25-50 cm), moderately shallow (50-75 cm), moderately deep (75-100 cm), deep (100-150 cm) and very deep (>150 cm). They were used to classify the soils into different depth classes and a soil depth map was generated (Fig. 5.2).

Moderately shallow soils (50-75 cm) occupy an area of about 115 ha (16%) in the western, central and small patches in the southwestern and northeastern part of the microwatershed. Shallow (25-50 cm) soils occupy major area of about 240 ha (34%) and are distributed in the western, central, small patches in southwestern and northeastern part of the microwatershed. Moderately deep (75-100 cm) soils occupy an area of about 44 ha (6%) and are distributed in the southern and central part of the microwatershed. Deep (100-150 cm) soils cover about 176 ha (25%) and occur in the western, central and southeastern part of the microwatershed and124 ha (17%) area is covered with rock outcrops.

The most problem lands with an area of about 240 ha (34%) having shallow 25-50 cm) rooting depth occur in the western, central and eastern part of the microwatershed.

They are not suitable for growing agricultural crops but well suited for pasture, forestry or other recreational purposes. Occasionally, short duration crops may be grown if rainfall is normal. The most productive soils cover 31 per cent that are moderately deep (75-100 cm) to deep (100-150 cm) and have potential for growing both annual and perennial crops.

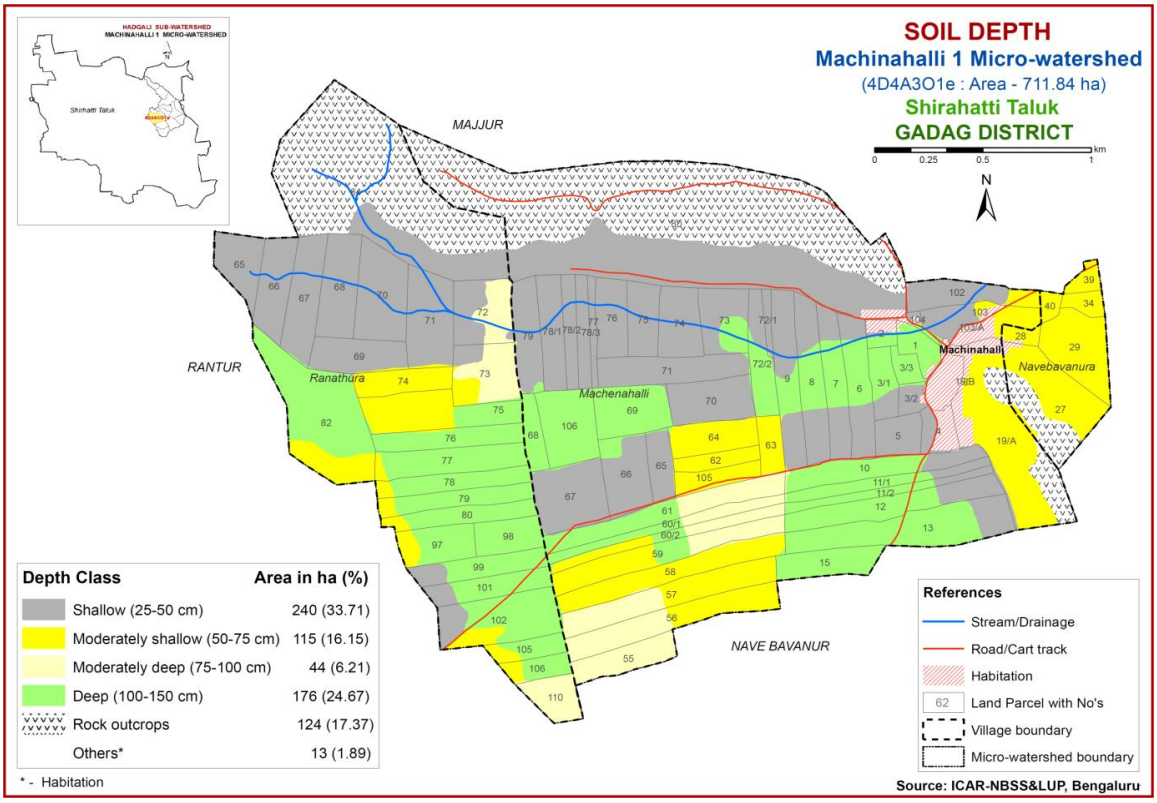


Fig. 5.2 Soil Depth map of Machinahalli-1 Microwatershed

5.3 Surface Soil Texture

Texture is an expression to indicate the coarseness or fineness of the soil as determined by the relative proportion of primary particles of sand, silt and clay. It has a direct bearing on the structure, porosity, adhesion and consistence. The surface layer of a soil to a depth of about 25 cm is the layer that is most used by crops and plants. The surface soil textural class provides a guide to understanding soil-water retention and availability, nutrient holding capacity, infiltration, workability, drainage, physical and chemical behaviour, microbial activity and crop suitability.

Maximum area of 243 ha (34%) has soils that are loamy at the surface and are distributed in the western, central and eastern part of the microwatershed. An area of about 333 ha (47%) have soils are clayey at the surface and occur in the southern, central and eastern part of the microwatershed (Fig. 5.3).

The most productive lands (81%) with respect to surface soil texture are the loamy and clayey soils that have high potential for soil-water retention and availability, and

nutrient retention and availability, but clayey soils have problems of drainage, infiltration, workability and other physical problems.

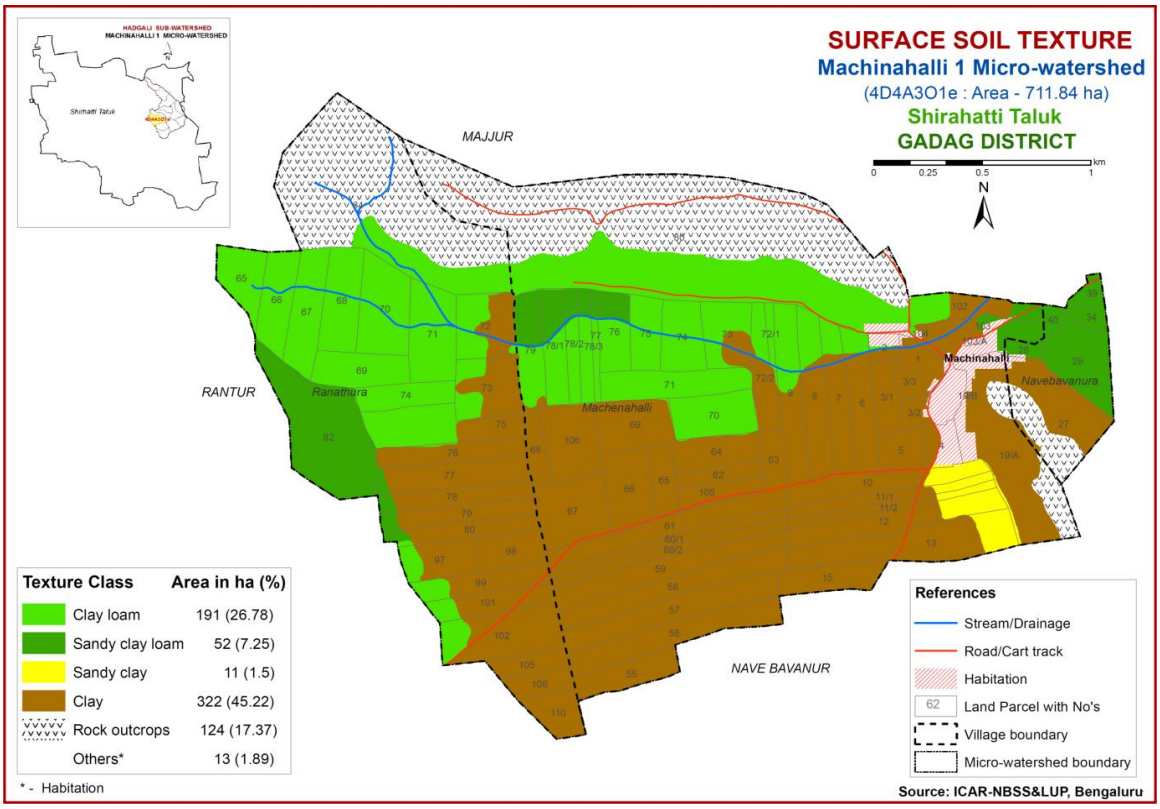


Fig. 5.3 Surface Soil Texture map of Machinahalli-1 Microwatershed

5.4 Soil Gravelliness

Gravel is the term used for describing coarse fragments between 2 mm and 7.5 cm diameter and stones for those between 7.5 cm and 25 cm. The presence of gravel and stones in soil reduces the volume of soil responsible for moisture and nutrient storage, drainage, infiltration and runoff and hinders plant growth by impeding root growth and seedling emergence, intercultural operations and farm mechanization.

About 118 ha (17%) area in the microwatershed has soils that are very gravelly (35-60%) and are distributed in the western, central and southeastern part of the microwatershed (Fig. 5.4). Maximum area of 320 ha (45%) is covered by gravelly (15-35%) soils and are distributed in the western, central, southeastern and eastern part of the microwatershed. The soils that are non-gravelly (<15%) cover an area of about 137 ha (19%) and are distributed in the southern and central parts of the microwatershed.

The most productive lands with respect to gravelliness are found to be 137 ha (19%). The problem soils (17%) that are very gravelly (35-60%) where only short duration crops can be grown.

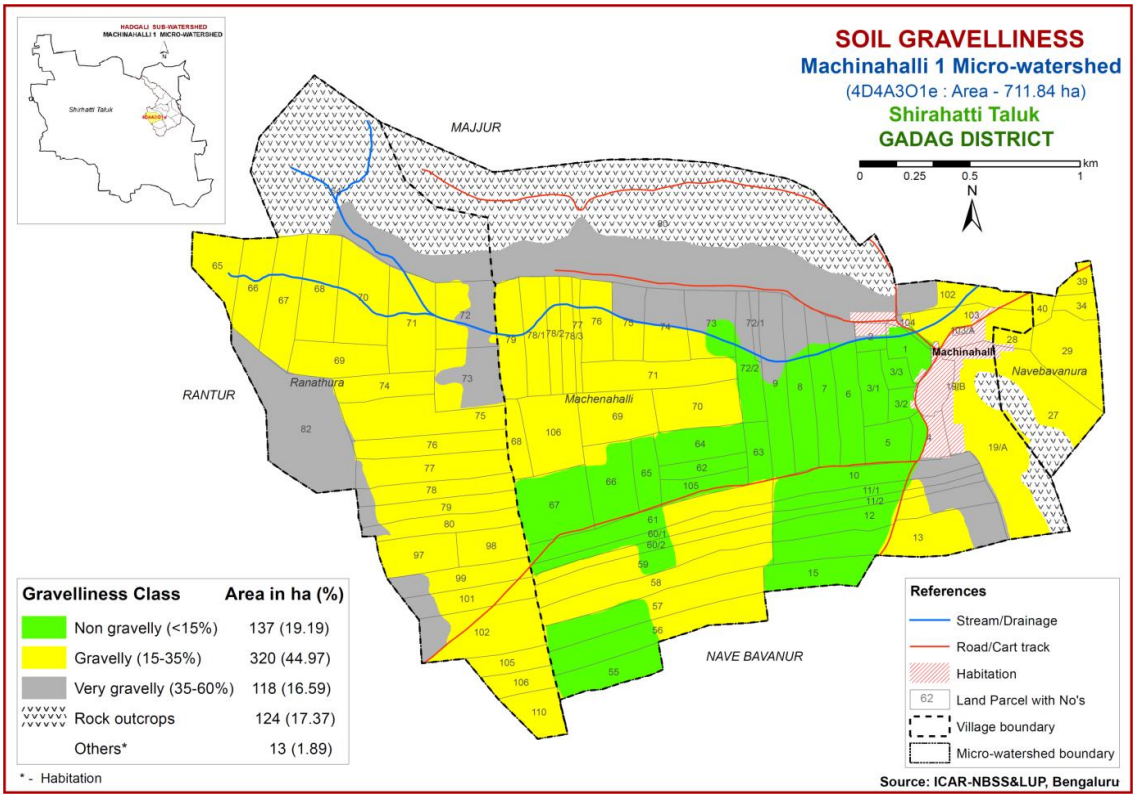


Fig. 5.4 Soil Gravelliness map of Machinahalli-1 Microwatershed

5.5 Available Water Capacity

The soil available water capacity (AWC) is estimated based on the ability of the soil column to retain water between the tensions of 0.33 and 15 bar in a depth of 100 cm or the entire solum if the soil is shallower. The AWC of the soils (soil series) as estimated by considering the soil texture, mineralogy, soil depth and gravel content (Sehgal *et al.*, 1990) and accordingly the soil map units were grouped into five AWC classes *viz*, very low (<50 mm/m), low (50-100 mm/m), medium (100-150 mm/m), high (150-200 mm/m) and very high (>200 mm/m) and using these values, an AWC map was generateded (Fig. 5.5).

Major area of about 166 ha (23%) in the microwatershed has soils that are very low (<50mm/m) in available water capacity and are distributed in the northwestern, central and eastern part of the microwatershed. An area of about 161 ha (23%) is low (51-100 mm/m) in available water capacity and are distributed in the western, central and eastern part of the microwateshed. An area of about 89 ha (12%) is medium (101-150 mm/m) in available water capacity and are distributed in the southern part of the microwatershed. Soils with very high available water capacity (>200 mm/m) occupy an area of about 160 ha (22%) and are distributed in the central and southeastern part of the microwatershed.

Major area in the microwatershed has soils that are problematic with regard to available water capacity. Here, only short or medium duration crops can be grown and the probability of crop failure is very high. These areas are best put to other alternative uses.

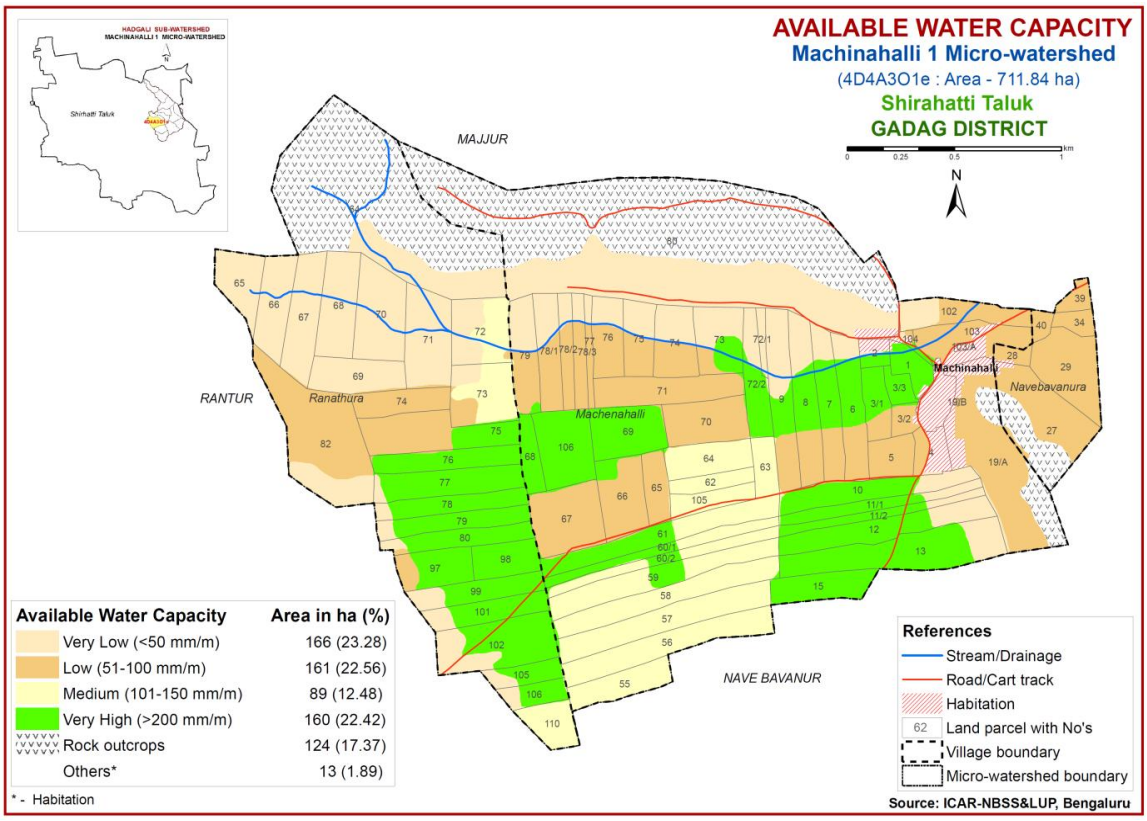


Fig. 5.5 Soil Available Water Capacity map of Machinahalli-1 Microwatershed

5.6 Soil Slope

Soil slope refers to the inclination of the surface of the land. It is defined by gradient, shape and length, and is an integral feature of any soil as a natural body. Slope is considered important in soil genesis, land use and land development. The length and gradient of slope influences the rate of runoff, infiltration, erosion and deposition. The soil map units were grouped into four slope classes and a slope map was generated showing the area extent and their geographic distribution of different slope classes in the microwatershed (Fig. 5.6).

Major area of about 448 ha (63%) falls under very gently sloping (1-3% slope) lands and is distributed in the western, central, southern and eastern part of the microwatershed. Gently sloping (3-5%) lands occupy an area of 118 ha (17%) and occur in the western, central and eastern part of the microwatershed. A very small area of about 9 ha (1%) is nearly level lands and are distributed in the southeastern part of the microwatershed.

All climatically adapted annual and perennial crops can be grown without much soil and water conservation and other land development measures in the areas where slopes are very gently sloping to nearly level (0-3%) lands.

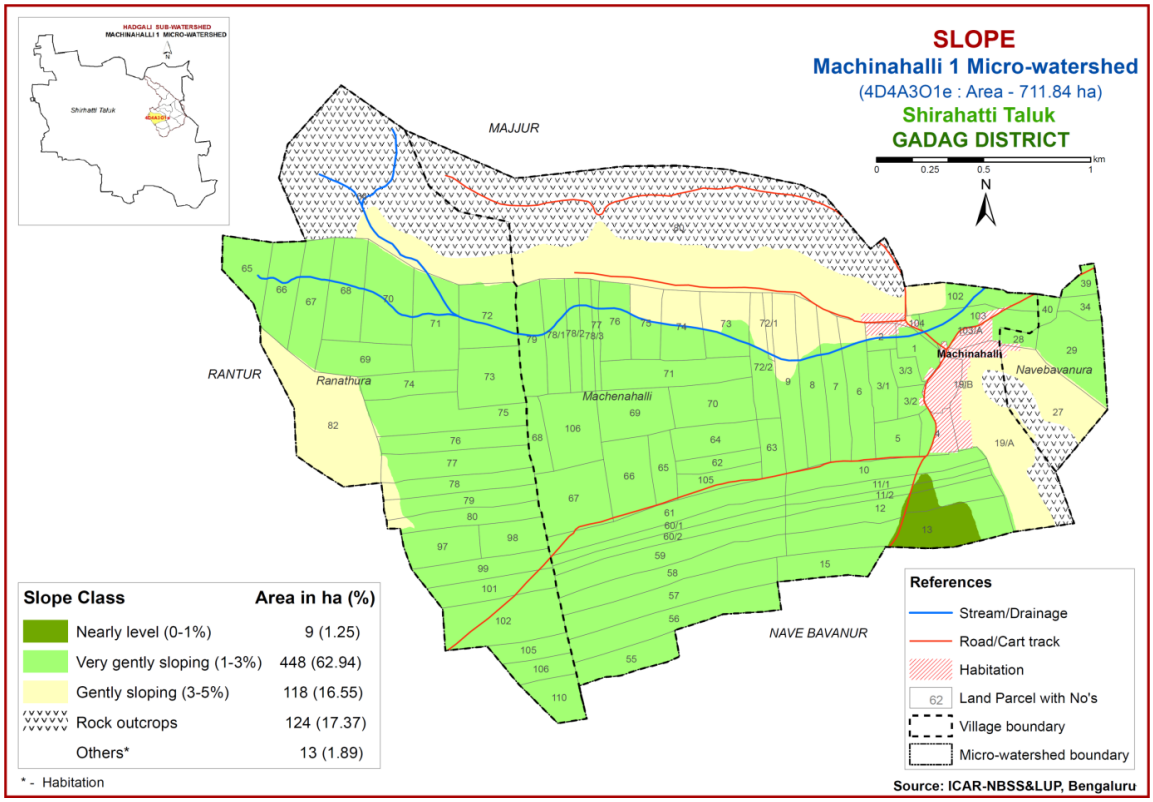


Fig. 5.6 Soil Slope map of Machinahalli-1 Microwatershed

5.7 Soil Erosion

Soil erosion refers to the wearing away of the earth's surface by the forces of water, wind and ice involving detachment and transport of soil by raindrop impact. It is used for accelerated soil erosion resulting from disturbance of the natural landscape by burning, excessive grazing and indiscriminate felling of forest trees and tillage, all usually by man. The erosion classes showing an estimate of the current erosion status as judged from field observations in the form of rills, gullies or a carpet of gravel on the surface are recorded. Four erosion classes, viz, slight erosion (e1), moderate erosion (e2), severe erosion (e3) and very severe erosion (e4) are recognized. The soil map units were grouped into different erosion classes and soil erosion map generated. The area extent and their spatial distribution in the microwatershed is given in Figure 5.7.

Soils that are moderately eroded (e2 class) cover maximum area of about 286 ha (40%) in the microwatershed. They are distributed in the southwestern, southern and central part of the microwatershed. Slightly eroded (e1 class) soils cover an area of about 118 ha (17%) and are distributed in the southern, central and eastern part of the microwatershed. Severely eroded (e3 class) soils cover an area of about 171 ha (24%) and occur in the northwestern, central and eastern part of the microwatershed.

An area of about 457 ha (64%) is problematic with respect to soil erosion. These areas need immediate soil and water conservation and other land development measures.

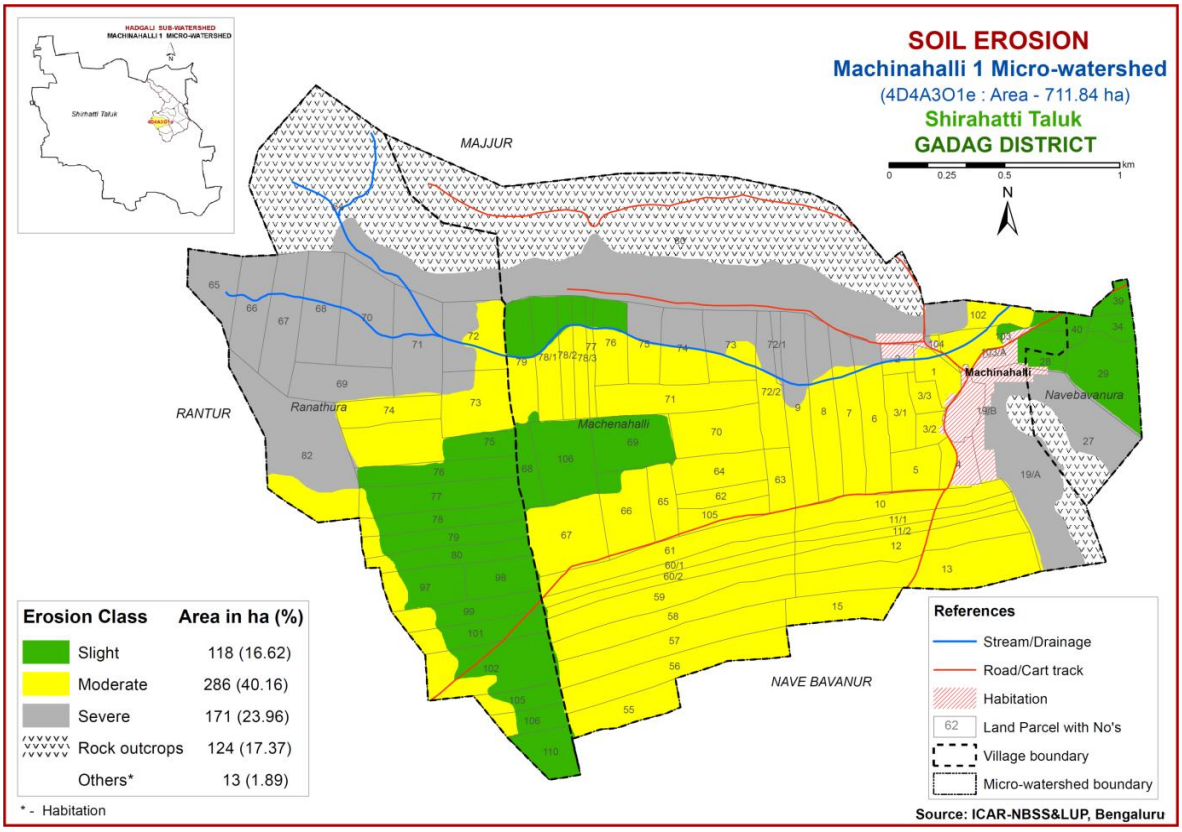


Fig. 5.7 Soil Erosion map of Machinahalli-1 Microwatershed

Chapter 6

FERTILITY STATUS

Soil fertility plays an important role in increasing crop yield. The adoption of high yielding varieties that require high amounts of nutrients has resulted in deficiency symptoms in crops and plants due to imbalanced fertilization and poor inherent fertility status as the area is characterised by low rainfall and high temperatures. Hence, it is necessary to know the fertility (macro and micro nutrients) status of the soils of the watersheds for assessing the kind and amount of fertilizers required for each of the crop intended to be grown. For this purpose, the surface soil samples collected from the grid points (one soil sample at every 250 m grid interval) all over the microwatershed through land resource inventory in the year 2014 were analysed for pH, EC, organic carbon, available phosphorus and potassium and for micronutrients like zinc, boron, copper, iron and manganese, and secondary nutrient sulphur.

Soil fertility data generated has been assessed and individual maps for all the nutrients for the microwatershed have been generated using kriging method under GIS. The village/survey number wise fertility data for the microwatershed is given in Appendix-II.

6.1 Soil Reaction (pH)

The soil analysis of the Machinahalli-1 microwatershed for soil reaction (pH) showed that an area of about 129 ha (18%) is moderately alkaline (pH 7.8-8.4) and is distributed in the southwestern, central and eastern part of the microwatershed. Maximum area of about 275 ha (39%) is under strongly alkaline (pH 8.4-9.0) and occur in the southeastern and central part of the microwatershed. Slightly alkaline (pH 7.3-7.8) soils occupy an area of about 65 ha (9%) and are distributed in the western, central and eastern part of the microwatershed. An area of about 105 ha (15%) is neutral (6.5-7.3) and are distributed in the western and eastern part of the microwatershed (Fig.6.1).

6.2 Electrical Conductivity (EC)

The Electrical Conductivity of the soils of the entire microwatershed area is <2 dSm^{-1} (Fig 6.2) and as the soils are nonsaline.

6.3 Organic Carbon

The soil organic carbon content (an index of available Nitrogen) of the microwatershed is medium (0.5-0.75%) covering an area of about 241 ha (34%) and is distributed in the western, southern, central and southeastern part of the microwatershed. An area of about 60 ha (8%) is low in organic carbon and are distributed in the western and central part of the microwatershed. Maximum area of 274 ha (38%) is high (>0.75%) in organic carbon content and occur in the southern, western, central and eastern part of the microwatershed (Fig.6.3).

6.4 Available Phosphorus

Available phosphorus content of the soils is low (<23 kg/ha) in maximum area of about 364 ha (51%) and are distributed in the western, central, southeastern and eastern part of the microwatershed. An area of about 210 ha (29%) is medium in available phosphorus and occur in the southern and central part of the microwatershed (Fig 6.4).

6.5 Available Potassium

Available potassium content is medium (145-337 kg/ha) in maximum area of about 320 ha (45%) and is distributed in all parts of the microwatershed (Fig.6.5). High available potassium (>337 kg/ ha) content accounts for 255 ha (36%) and is distributed in the central, eastern, southeastern and small patch in the western part of the microwatershed.

6.6 Available Sulphur

Major area of about 319 ha (45%) is medium (10-20 ppm) in available sulphur and are distributed in the western, southern, central and southeastern part of the microwatershed. An area of about 256 ha (36%) is low (<10 ppm) and occur in the western, southern and eastern part of the microwatershed (Fig.6.6).

6.7 Available Boron

Available boron content is medium (0.5-1.0 ppm) in an area of 268 ha (38%) in the microwatershed and is distributed in the western, central and southeastern part of the microwatershed. Maximum area of about 299 ha (42%) is low (<0.5 ppm) in available boron occur in the southwestern, central and eastern part of the microwatershed (Fig.6.7). Available boron content is high (>1.0 ppm) in a very small area of 8 ha (1%) and is distributed in the south eastern part of the microwatershed.

6.8 Available Iron

Available iron content is sufficient (>4.5 ppm) in an area of 41 ha (6%) and are distributed in the western and southeastern part of the microwatershed. Maximum area of about 533 ha (75%) is deficient (<4.5 ppm) in available iron content and is distributed in all part of the microwatershed (Fig 6.8).

6.9 Available Manganese

Available manganese content is sufficient (>1.0 ppm) in the entire microwatershed area (Fig 6.9).

6.10 Available Copper

Available copper content is sufficient (>0.2 ppm) in the entire microwatershed area (Fig 6.10).

6.11 Available Zinc

Available zinc content is sufficient (>0.6 ppm) in an area of 115 ha (16%) and is distributed in the central and eastern part of the microwatershed. Major area of about 459 ha (64%) is deficient (<0.6 ppm) in available zinc content and occur in the western, central and southern part of the microwatershed (Fig 6.11).

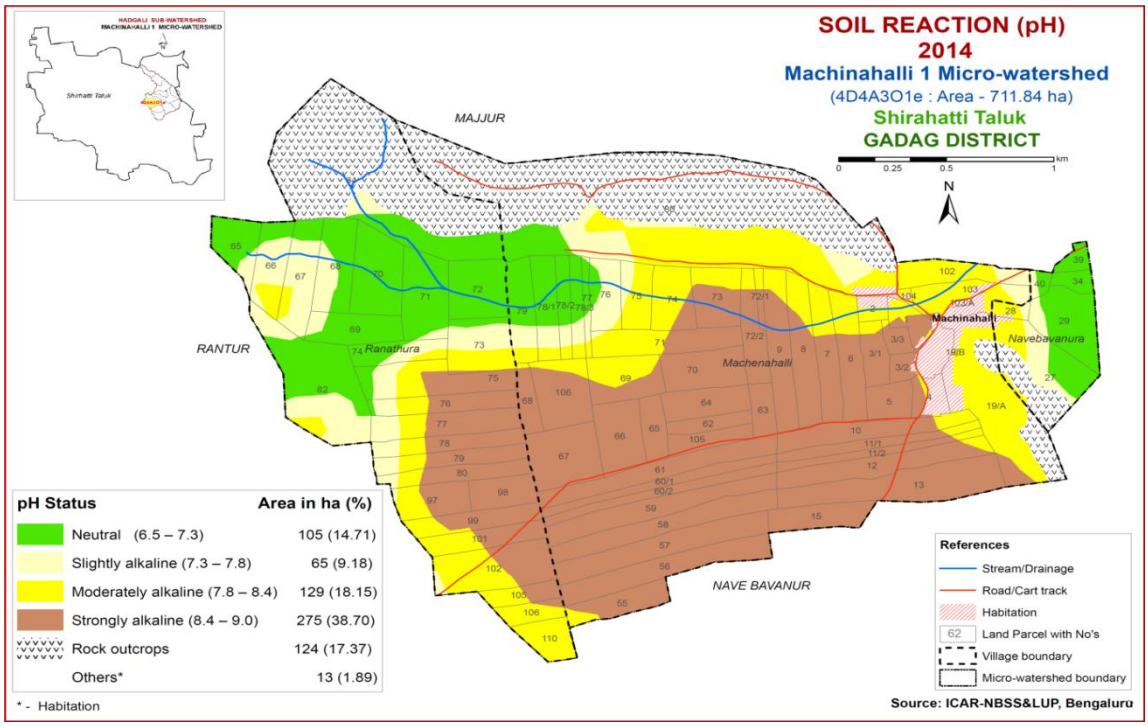


Fig.6.1 Soil Reaction (pH) map of Machinahalli-1 Microwatershed

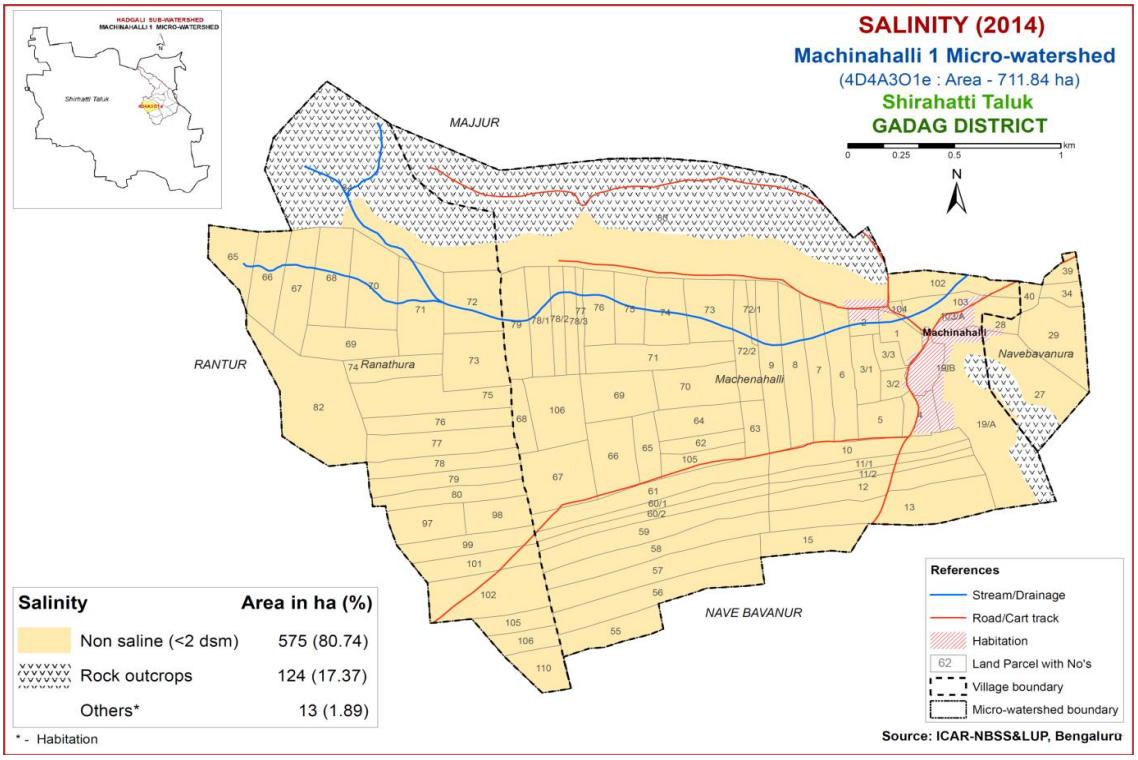


Fig.6.2 Electrical Conductivity (EC) map of Machinahalli-1 Microwatershed

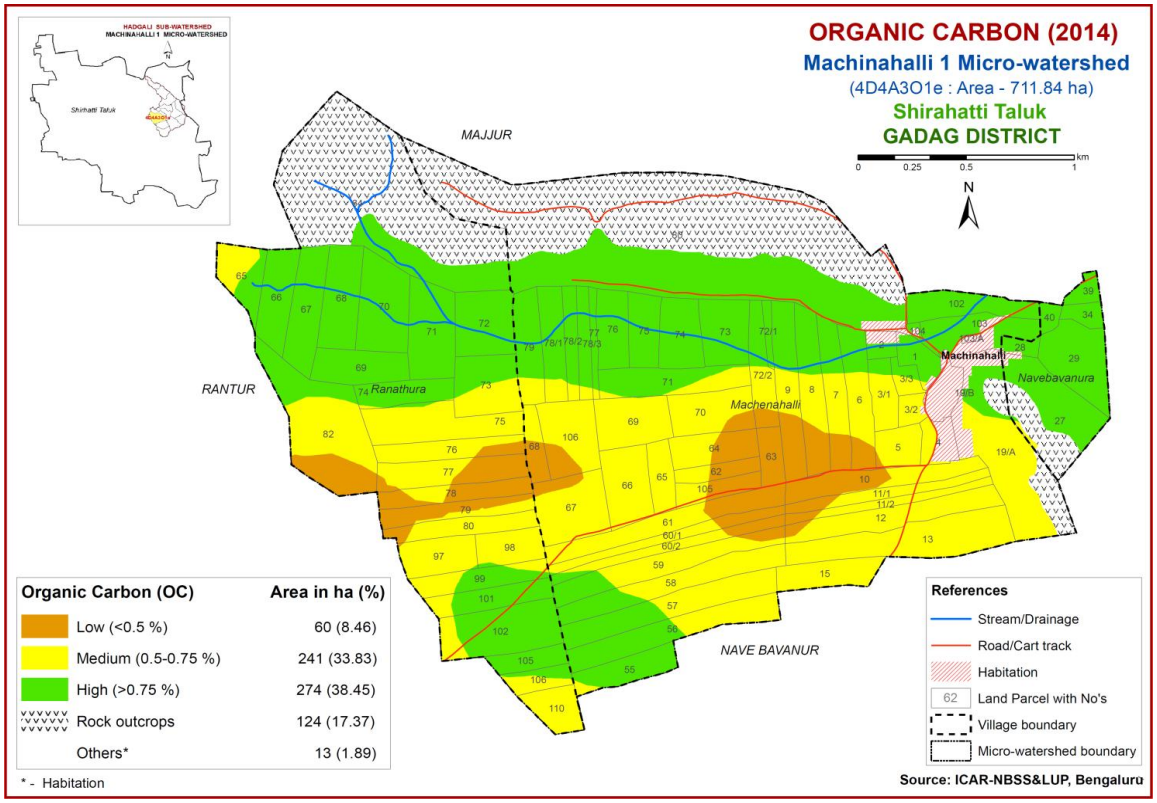


Fig.6.3 Soil Organic Carbon map of Machinahalli-1 Microwatershed

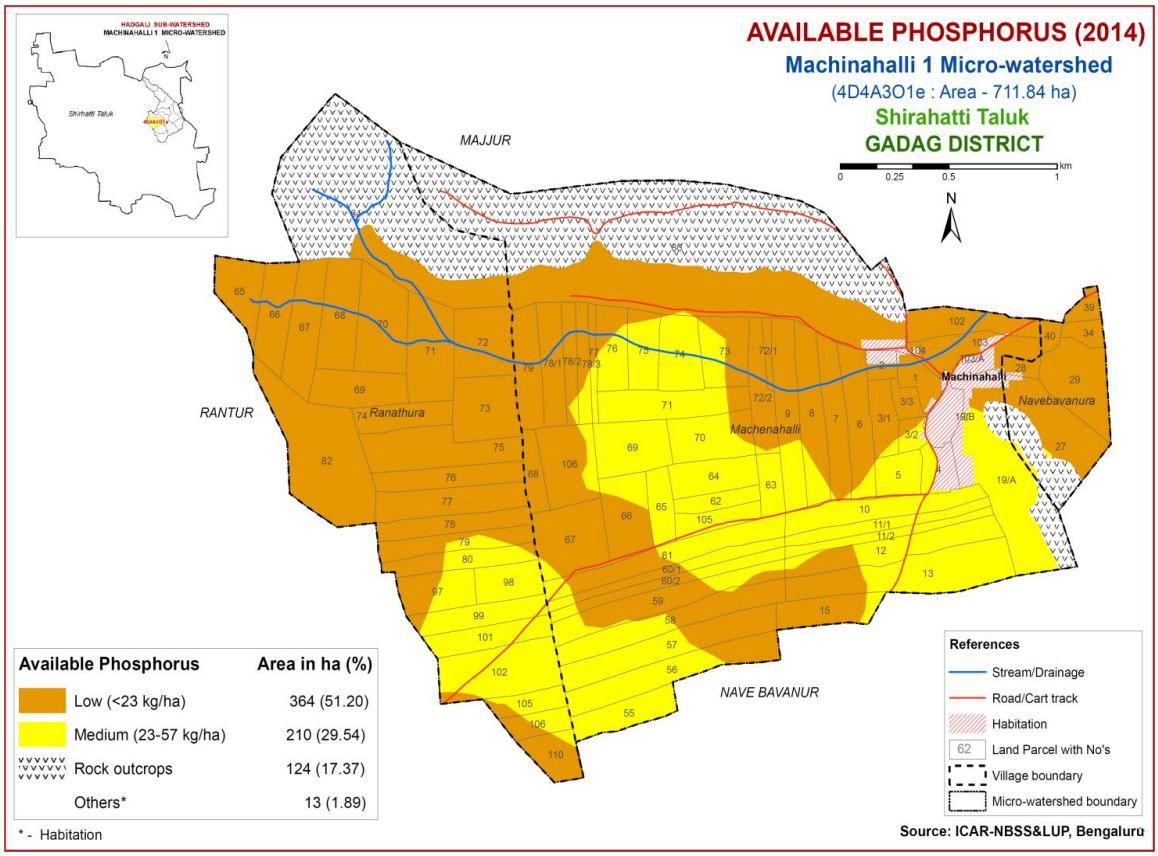


Fig.6.4 Soil Available Phosphorus map of Machinahalli-1 Microwatershed

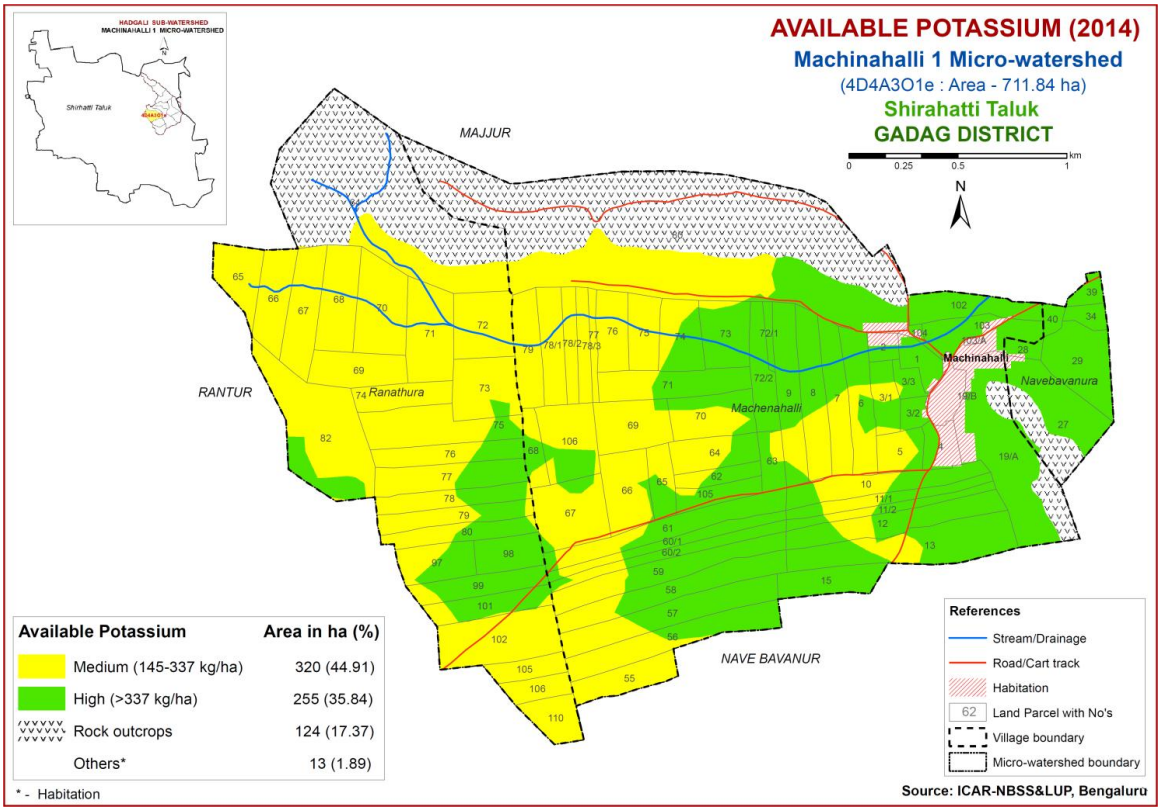


Fig.6.5 Soil Available Potassium map of Machinahalli-1 Microwatershed

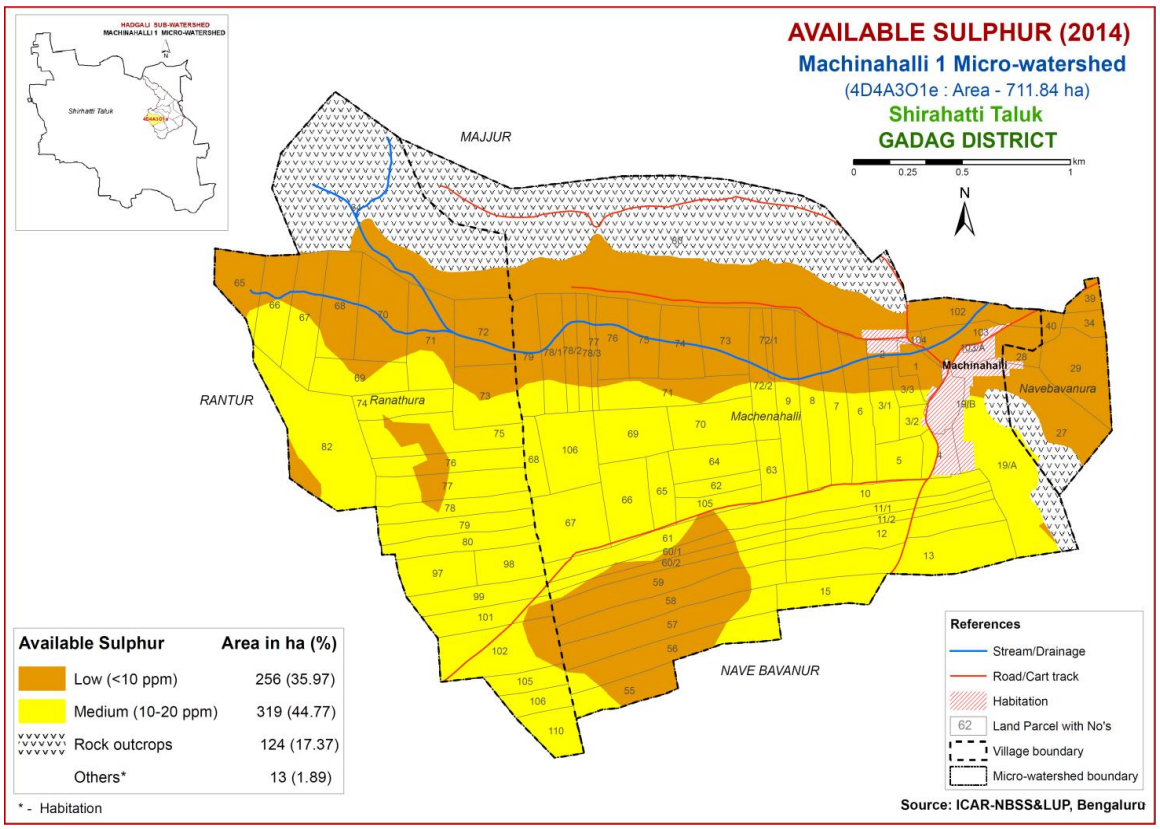


Fig.6.6 Soil Available Sulphur map of Machinahalli-1 Microwatershed

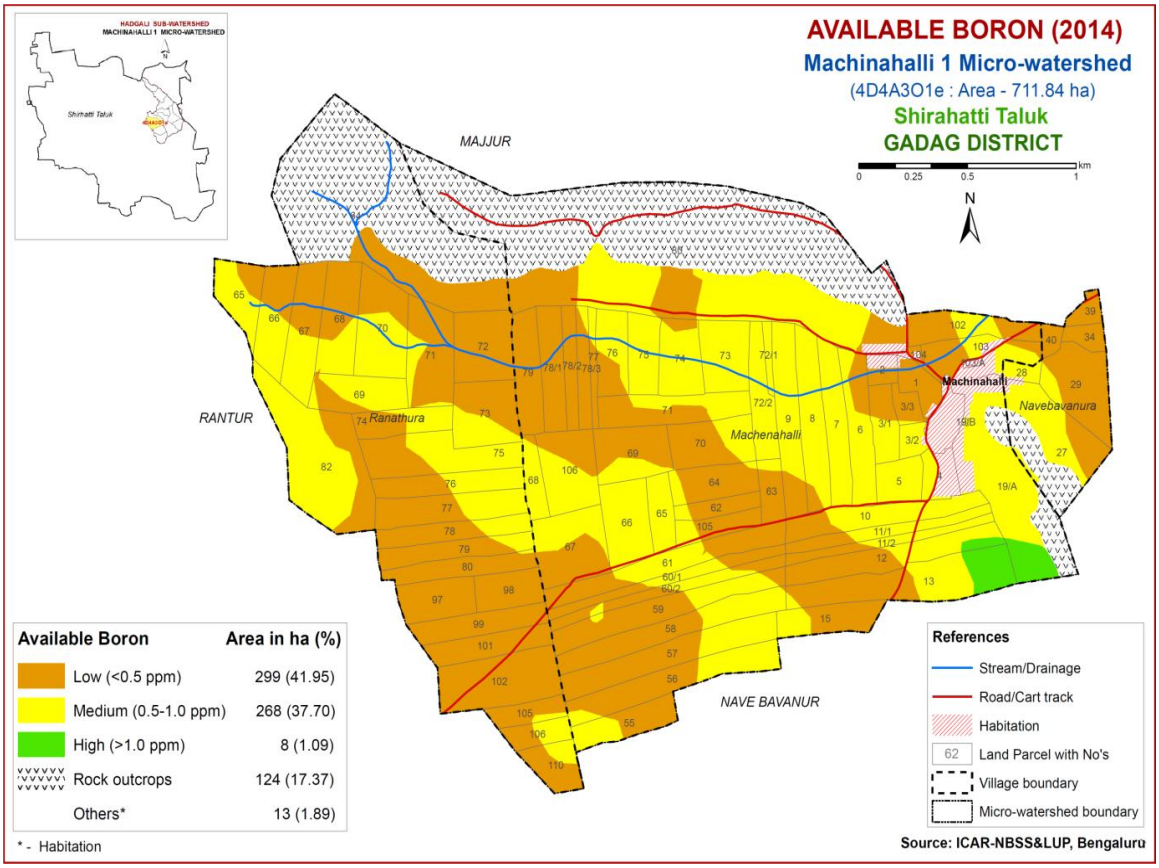


Fig.6.7 Soil Available Boron map of Machinahalli-1 Microwatershed

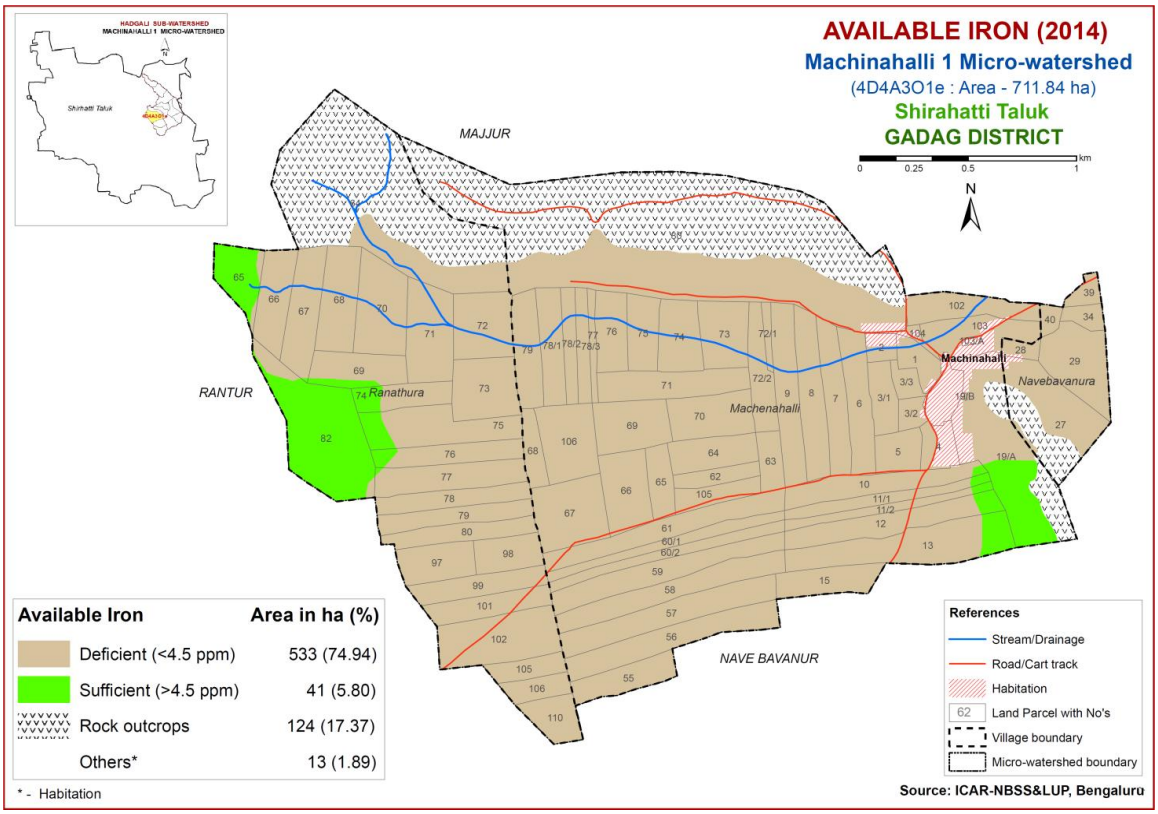


Fig.6.8 Soil Available Iron map of Machinahalli-1 Microwatershed

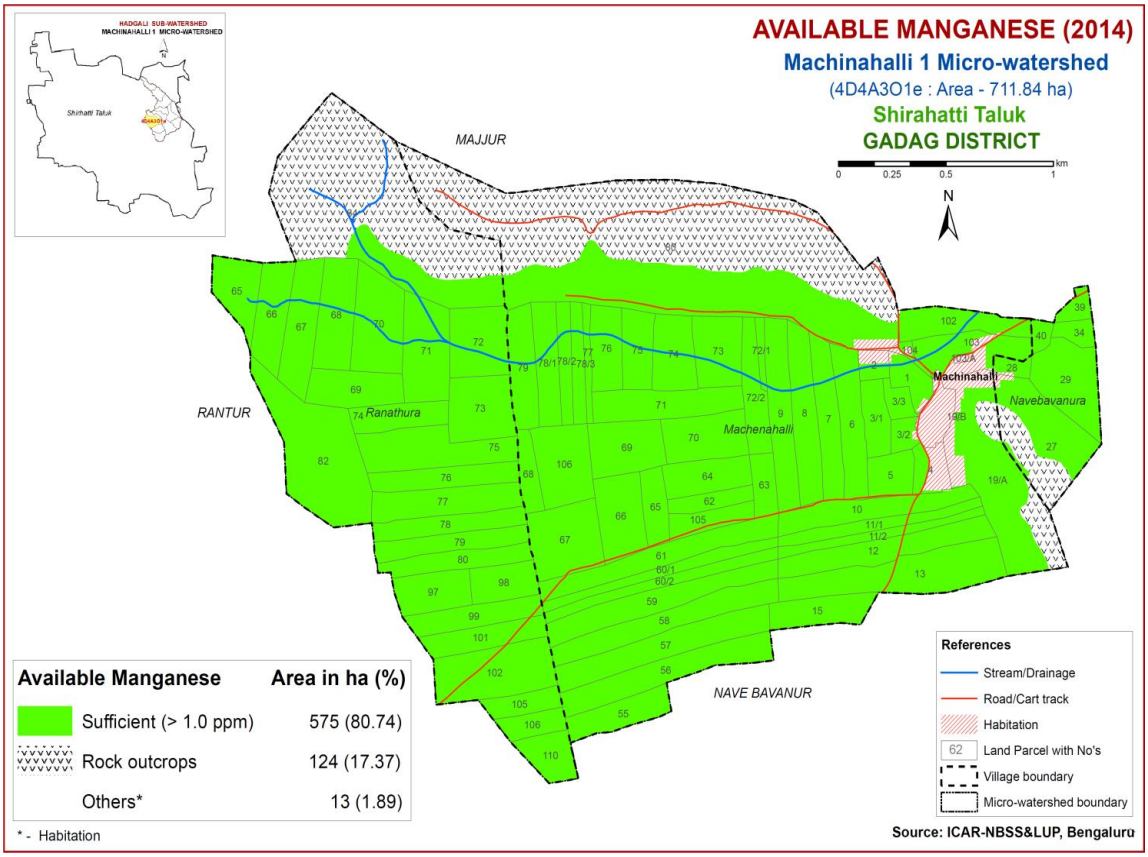


Fig.6.9 Soil Available Manganese map of Machinahalli-1 Microwatershed

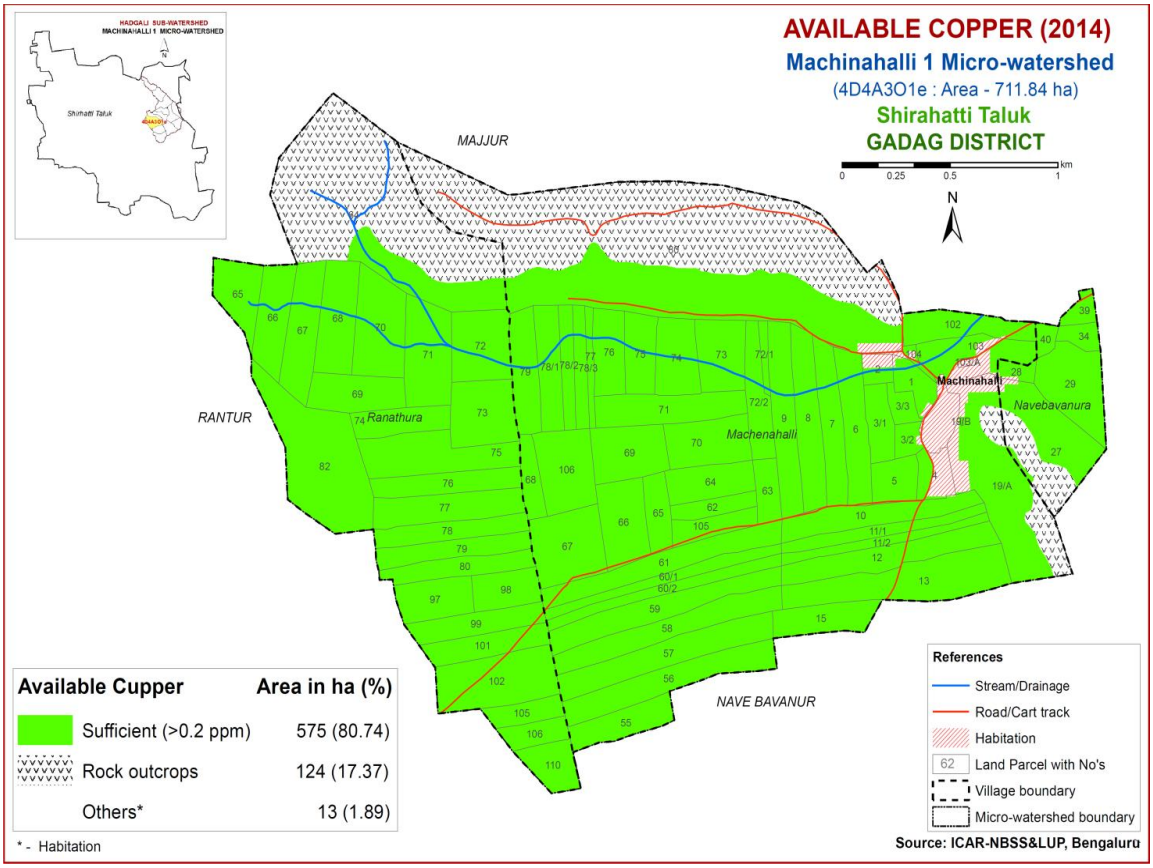


Fig.6.10 Soil Available Copper map of Machinahalli-1 Microwatershed

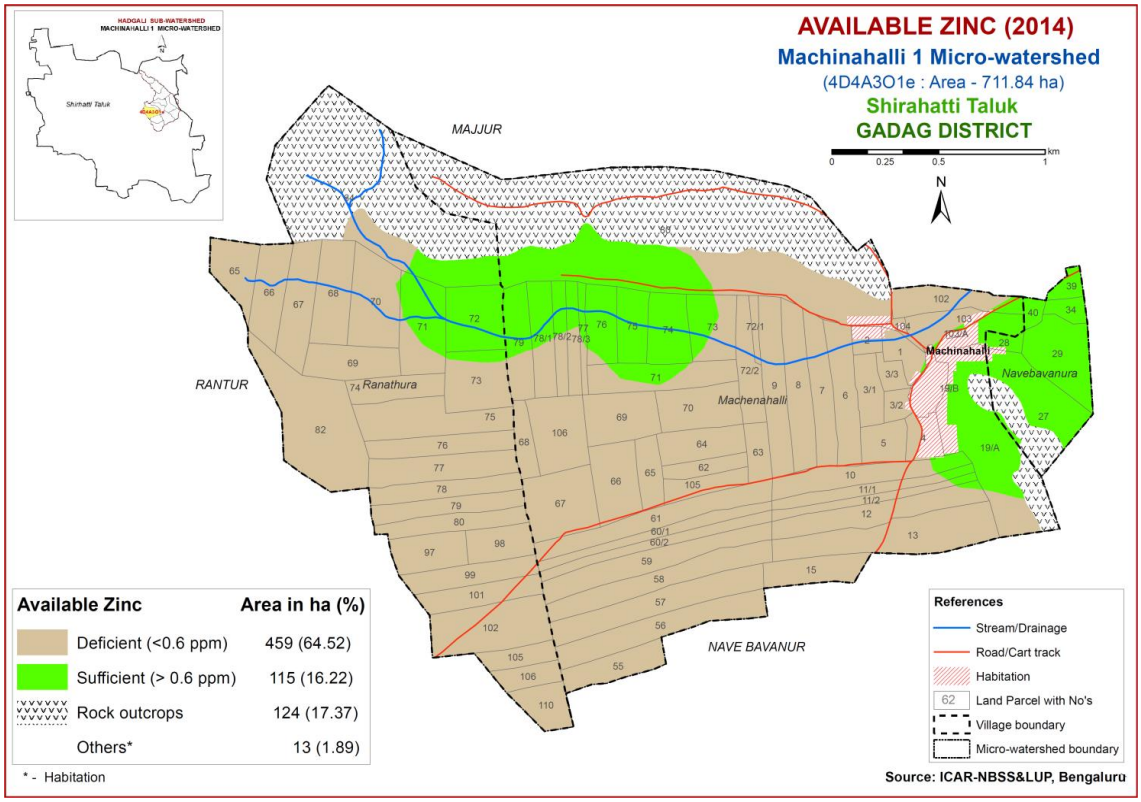


Fig.6.11 Soil Available Zinc map of Machinahalli-1 Microwatershed

Chapter 7

LAND SUITABILITY FOR MAJOR CROPS

The soil and land resource units (soil phases) of Machinahalli-1 Microwatershed were assessed for their suitability for growing food, fodder, fibre and other horticulture crops by following the procedure as outlined in FAO, 1976 and 1983. Crop requirements were developed for each of the crop from the available research data and also by referring to Naidu *et. al.* (2006) and Natarajan *et. al* (2015). The crop requirements were matched with the soil and land characteristics (Table 7.1) to arrive at the crop suitability. In FAO land suitability classification, two orders are recognized. Order S- Suitable and Order N- Not suitable. The orders have classes, subclasses and units. Order-S has three classes, class S1- Highly Suitable, class S2- Moderately Suitable and class S3- Marginally Suitable. Order N has two classes, N1- Currently not Suitable and N2- Permanently not Suitable. There are no subclasses within the class S1 as they will have very minor or no limitations for crop growth. Classes S2 and S3 are divided into subclasses based on the kinds of limitations encountered. The limitations that affect crop production are 'c' for erratic rainfall and its distribution and length of growing period (LGP), 'e' for erosion hazard, 'r' for rooting condition, 't' for lighter or heavy texture, 'g' for gravelliness or stoniness, 'n' for nutrient availability, 'l' for topography, 'm' for moisture availability, 'z' for calcareousness and 'w' for drainage. These limitations are indicated as lower case letters to the class symbol. For example, moderately suitable land with the limitations of soil depth and erosion is designated as S2re. For the microwatershed, the soil mapping units were evaluated and classified up to subclass level.

Using the above criteria, the soil map units of the microwatershed were evaluated and land suitability maps for 23 major agricultural and horticultural crops were generated. The detailed information on the kind of suitability of each of the soil phase for the crops assessed are given village/ survey number wise for the microwatershed in Appendix-III.

7.1 Land Suitability for Sorghum (*Sorghum bicolor*)

Sorghum is one of the major crops grown in Karnataka in an area of 10.47 lakh ha in Bijapur, Gulbarga, Raichur, Bidar, Belgaum, Dharwad, Bellary, Chitradurga, Mysore and Chamarajnagar districts. The crop requirements for growing sorghum (Table 7.2) were matched with the soil-site characteristics (Table 7.1) of the soils of the microwatershed and a land suitability map for growing sorghum was generated. The area extent and their geographic distribution of different suitability subclasses in the microwatershed are given in Figure. 7.1.

Highly suitable (Class S1) lands occupy an area of about 195 ha (27%) for growing sorghum and occur in the southern, central and southeastern part of the microwatershed. An area of about 130 ha (18%) is moderately suitable (Class S2) for growing sorghum and are distributed in the western, central, eastern and southern part the microwatershed.

Table 7.1 Soil-Site Characteristics of Machinahalli-1 Microwatershed

Soil Map Units	Climate (P) (mm)	Growing period (Days)	Drai-nage Class	Soil depth (cm)	Soil texture		Gravelliness		AWC (mm/m)	Slope (%)	Erosion	pH	EC (dSm^{-1})	ESP (%)	CEC [Cmol $(p^{+})kg^{-1}$]	BS (%)
					Surf-ace	Sub-surface	Surface (%)	Sub surface (%)								
ATTmB2	633	150	WD	50-75	c	c	-	-	50-100	1-3	moderate	8.32	0.1	0.14	56.32	100
ATTmB2g1	633	150	WD	50-75	c	c	15-35	-	50-100	1-3	moderate	8.32	0.1	0.14	56.32	100
BPRhC3g2	633	150	WD	100-150	scl	sc-c	35-60	>35	100-150	3-5	severe	6.64	0.03	0.51	5.45	63.48
JLGmB2	633	150	WD	75-100	c	c	-	-	150-200	1-3	moderate	8.24	0.07	0.57	53.81	100
JLGmB1g1	633	150	WD	75-100	c	c	15-35	-	150-200	1-3	slight	8.24	0.07	0.57	53.81	100
JLGmB2g1	633	150	WD	75-100	c	c	15-35	-	150-200	1-3	moderate	8.24	0.07	0.57	53.81	100
JLGmB2g2	633	150	WD	75-100	c	c	35-60	-	150-200	1-3	moderate	8.24	0.07	0.57	53.81	100
KGPfB2g2	633	150	WD	25-50	cl	scl-sc	35-60	15-35	50-100	1-3	moderate					
KGPfB3g1	633	150	WD	25-50	cl	scl-sc	15-35	15-35	50-100	1-3	severe					
KGPfC3g2	633	150	WD	25-50	cl	scl-sc	35-60	15-35	50-100	3-5	severe					
KGPfC3g2 R2St2	633	150	WD	25-50	cl	scl-sc	35-60	15-35	50-100	3-5	severe					
KGPhB1g1	633	150	WD	25-50	scl	scl-sc	15-35	15-35	50-100	1-3	slight					
KGPiB2g2	633	150	WD	25-50	sc	scl-sc	35-60	15-35	50-100	1-3	moderate					
KTPhB1g1	633	150	WD	50-75	scl	scl	15-35	15-35	100-150	1-3	slight					
KTPmC3g1	633	150	WD	50-75	c	scl	15-35	15-35	100-150	3-5	severe					
LKRhC2g2	633	150	WD	50-75	scl	ls	35-60	35-60	50-100	3-5	moderate	8.18	0.30	4.51	12.19	100
MKHmB2g1	633	150	WD	50-75	c	scl	15-35	>35	50-100	1-3	moderate	7.38	0.09	1.49	14.48	93
MPTmA2g1	633	150	WD	100-150	c	c	15-35	-	200-250	0-3	moderate	8.41	0.09	0.21	53.58	100
MPTmB1g1	633	150	WD	100-150	c	c	15-35	-	200-250	1-3	slight	8.41	0.09	0.21	53.58	100
MPTmB2	633	150	WD	100-150	c	c	-	-	200-250	1-3	moderate	8.41	0.09	0.21	53.58	100
NPTfB2g1	633	150	WD	25-50	cl	c	15-35	10-20	100-150	1-3	moderate	8.52	0.1	0.25	39.33	100
TDHfB2g1	633	150	WD	50-75	cl	sc-c	15-35	-	100-150	1-3	moderate	9.19	0.18	14.57	3.57	100
YSJmB2	633	150	WD	25-50	c	cl-c	-	<15	50-100	1-3	moderate	8.57	0.23	0.90	52.12	100
YSJmB2g1	633	150	WD	25-50	c	cl-c	15-35	<15	50-100	1-3	moderate	8.57	0.23	0.90	52.12	100

*Symbols and abbreviations are according to Field Guide for LRI under Sujala-III Project, Karnataka

They have minor limitations of gravelliness and rooting depth. Marginally suitable lands (Class S3) for growing sorghum occupy major area of about 252 ha (35%) and occur in the northwestern, central and northeastern part of the microwatershed with moderate limitations of gravelliness, rooting depth and calcareousness.

Table 7.2 Crop suitability criteria for Sorghum

Crop requirement		Rating			
Soil –site characteristics	**Unit**	**Highly suitable (S1)**	**Moderately Suitable (S2)**	**Marginally suitable (S3)**	**Not suitable (N)**
Slope	%	2-3	3-8	8-15	>15
LGP	Days	120-150	120-90	<90	
Soil drainage	Class	Well to mod.Well drained	imperfect	Poorly/excessively	V.poorly
Soil reaction	pH	6.0-8.0	5.5-5.9 8.1-8.5	<5.5 8.6-9.0	>9.0
Surface soil texture	Class	c, cl, sicl, sc	l, sil, sic	Sl, ls	S, fragmental skeletal
Soil depth	Cm	100-75	50-75	30-50	<30
Gravel content	% vol.	5-15	15-30	30-60	>60
Salinity (EC)	dSm^{-1}	2-4	4-8	8-10	>10
Sodicity (ESP)	%	5-8	8-10	10-15	>15

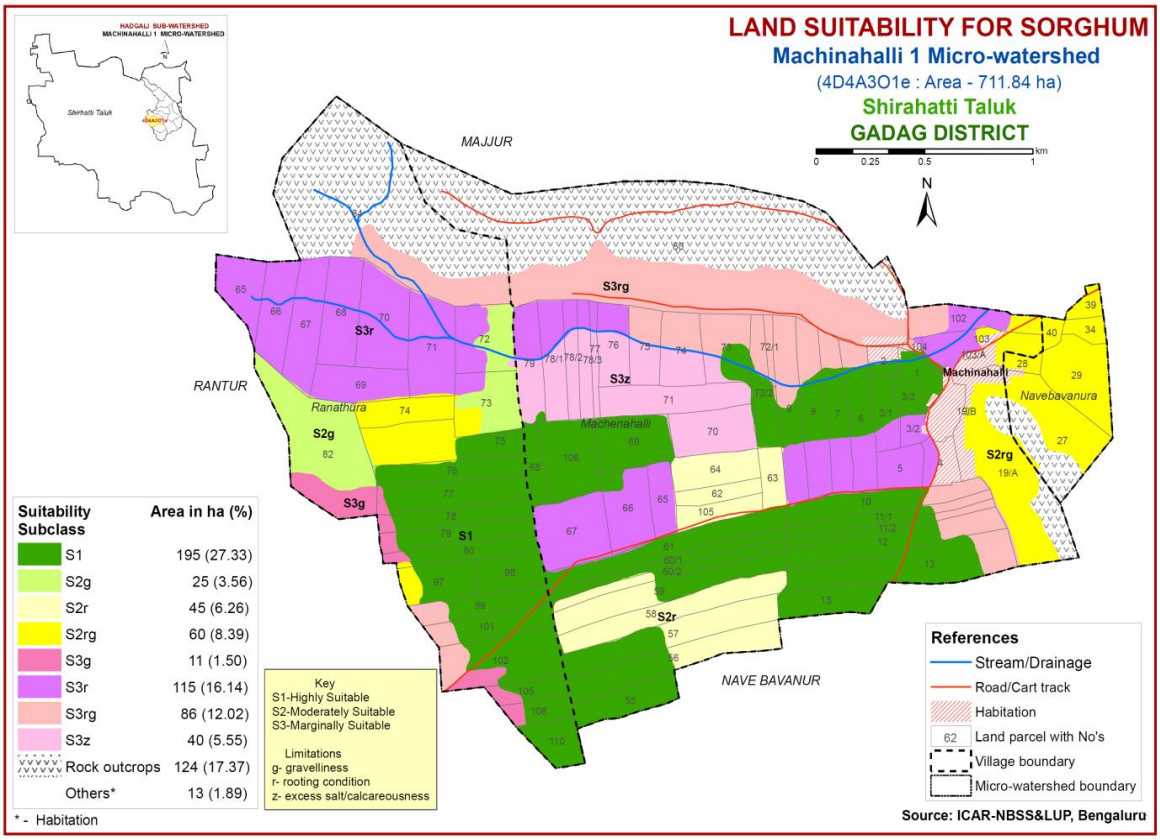


Fig. 7.1 Land Suitability map of Sorghum

7.2 Land Suitability for Maize (*Zea mays*)

Maize is the most important food crop grown in an area of 13.37 lakh ha in almost all the districts of the State. The crop requirements for growing maize (Table 7.3) were matched with the soil-site characteristics (Table 7.1) and a land suitability map for growing maize was generated. The area extent and their geographical distribution of different suitability subclasses in the microwatershed is given in Figure 7.2.

Table 7.3 Crop suitability criteria for Maize

Crop requirement		Rating			
Soil–site characteristics	**Unit**	**Highly suitable (S1)**	**Moderately suitable (S2)**	**Marginally suitable (S3)**	**Not suitable (N)**
Slope	%	<3	3.5	5-8	
LGP	Days	>100	100-80	60-80	
Soil drainage	Class	Well drained	Mod. to imperfectly	Poorly/excessively	V.poorly
Soil reaction	pH	5.5-7.5	7.6-8.5	8.6-9.0	
Surface soil texture	Class	l, cl, scl, sil	Sl, sicl, sic	C(s-s), ls	S,fragmental
Soil depth	Cm	>75	50-75	25-50	<25
Gravel content	% vol.	<15	15-35	35-50	>50
Salinity (EC)	dSm^{-1}	<1.0	1.0-2.0	2.0-4.0	
Sodicity (ESP)	%	<10	10-15	>15	

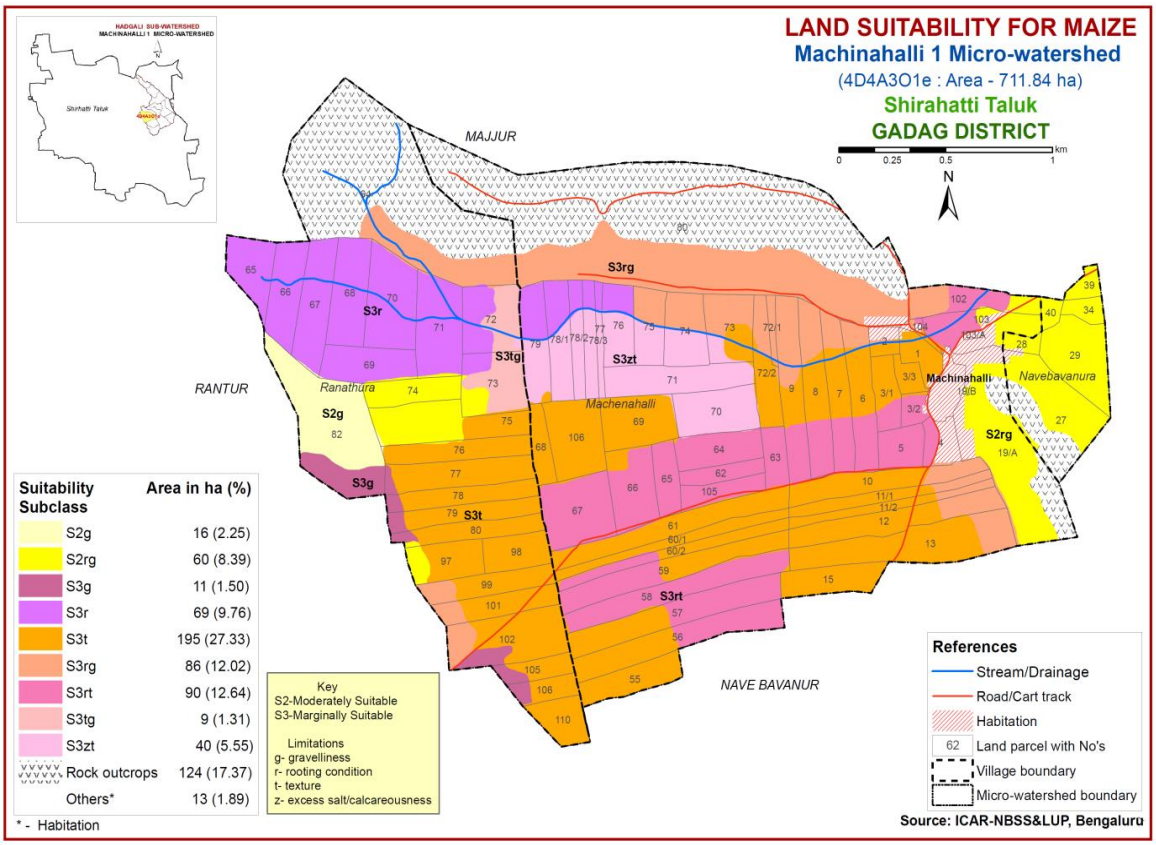


Fig. 7.2 Land Suitability map of Maize

There are no highly suitable (Class S1) lands for growing maize. Moderately suitable (Class S2) lands occupy an area of about 76 ha (11%) and are distributed in the western and eastern part of the microwatershed. They have minor limitations of gravelliness and rooting depth. Marginally suitable lands (Class S3) for growing sorghum occupy major area of about 500 ha (70%) and occur in the western, southwestern, central and southeastern part of the microwatershed with moderate limitations of gravelliness, rooting depth, texture and calcareousness.

7.3 Land Suitability for Cotton (*Gossypium hirsutum*)

Cotton is the most important fibre crop grown in the State in about 6.6 lakh ha area in Raichur, Dharwad, Belgaum, Gulbarga, Bijapur, Bidar, Bellary, Chitradurga and Chamarajnagar districts. The crop requirements for growing cotton (Table 7.4) were matched with the soil-site characteristics (Table 7.1) and a land suitability map for growing cotton was generated. The area and their geographical distribution of different suitability subclasses in the microwatershed is given in Figure 7.3.

Highly suitable (Class S1) lands occupy an area of about 160 ha (22%) for growing cotton and occur in the central and southeastern part of the microwatershed. An area of about 165 ha (23%) has soils that are moderately suitable (Class S2) with minor limitations of gravelliness and rooting depth. They are distributed in the western, southern and eastern part of the microwatershed. The marginally suitable (Class S3) lands cover an area of about 251 ha (35%) and occur in the northwestern, southwestern, central and eastern part of the microwatershed. They have moderate limitations of gravelliness, rooting depth and calcareousness.

Table 7.4 Crop suitability criteria for Cotton

Crop requirement		Rating			
Soil–site characteristics	**Unit**	**Highly suitable (S1)**	**Moderately suitable (S2)**	**Marginally suitable (S3)**	**Not suitable (N)**
Slope	%	1-2	2-3	3-5	>5
LGP	Days	180-240	120-180	<120	
Soil drainage	Class	Well to moderately well	Imperfectly drained	Poor somewhat excessive	Stagnant/ Excessive
Soil reaction	pH	6.5-7.5	7.6-8.0	8.1-9.0	>9.0>6.5
Surface soil texture	Class	Sic, c	Sicl, cl	Si, sil, sc, scl, l	Sl, s,ls
Soil depth	Cm	100-150	60-100	30-60	<30
Gravel content	% vol.	<5	5-10	10-15	15-35
$CaCO_3$ in root zone	%	<3	3-5	5-10	10-20
Salinity (EC)	dSm^{-1}	2-4	4.0-8.0	8.0-12	>12
Sodicity (ESP)	%	5-10	10-20	20-30	>30

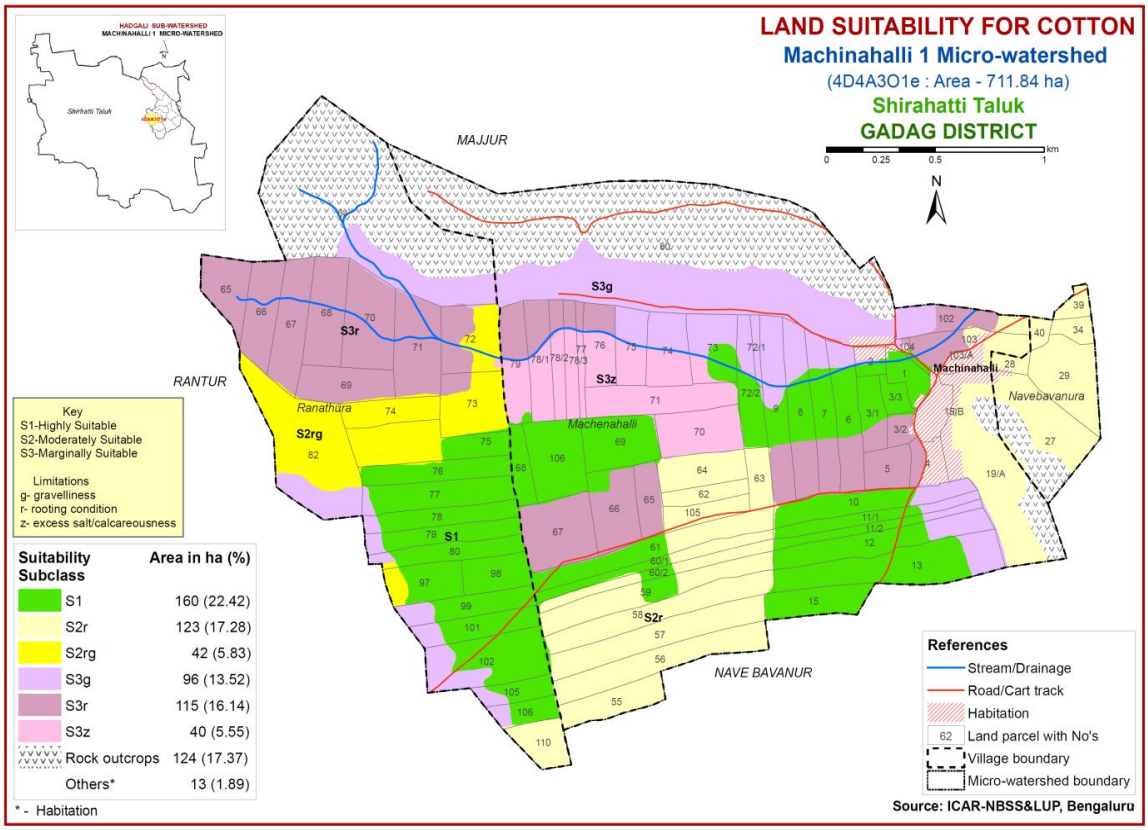


Fig. 7.3 Land Suitability map of Cotton

7.4 Land Suitability for Sunflower (*Helianthus annus*)

Sunflower is the most important oilseed crop grown in an area of 3.56 lakh ha in the State in all the districts. The crop requirements for growing sunflower (Table 7.5) were matched with the soil-site characteristics (Table 7.1) and a land suitability map for growing sunflower was generated (Fig. 7.4). The area extent and their geographical distribution of different suitability subclasses in the microwatershed is given in Table 7.5.

Highly suitable (Class S1) lands occupy an area of about 160 ha (22%) for growing sunflower and occur in the central and southwestern part of the microwatershed. Moderately suitable (Class S2) lands occupy an area of about 61 ha (8%) and are distributed in the southern and central part of the microwatershed with minor limitations of rooting depth and gravelliness. An area of about 115 ha (16%) is marginally suitable (Class S3) lands and distributed in the western, southern, central and eastern part of the micro watershed. They have moderate limitations of rooting depth and gravelliness. Major area of about 240 ha (34%) is not suitable (Class N) and occur in the western, central, northeastern and southeastern part of the microwatershed with severe limitations of rooting depth, gravelliness and calcareousness.

Table 7.5 Land suitability criteria for Sunflower

Crop requirement		Rating			
Soil -site characteristics	**Unit**	**Highly suitable (S1)**	**Moderately suitable (S2)**	**Marginally suitable (S3)**	**Not suitable (N)**
Slope	%	<3	3-5	5-10	>10
LGP	Days	>90	80-90	70-80	<70
Soil drainage	Class	Well drained	Mod. Well rained	imperfectly drained	Poorly drained
Soil reaction	pH	6.5-8.0	8.1-8.5 5.5-6.4	8.6-9.0; 4.5-5.4	>9.0 <4.5
Sub Surface soil texture	Class	l, cl, sil, sc	cl, sic, c,	c (>60%), sl	ls, s
Soil depth	Cm	>100	75-100	50-75	<50
Gravel content	%vol.	<15	15-35	35-60	>60
Salinity (EC)	dsm^{-1}	<1.0	1.0-2.0	>2.0	
Sodicity (ESP)	%	<10	10-15	>15	

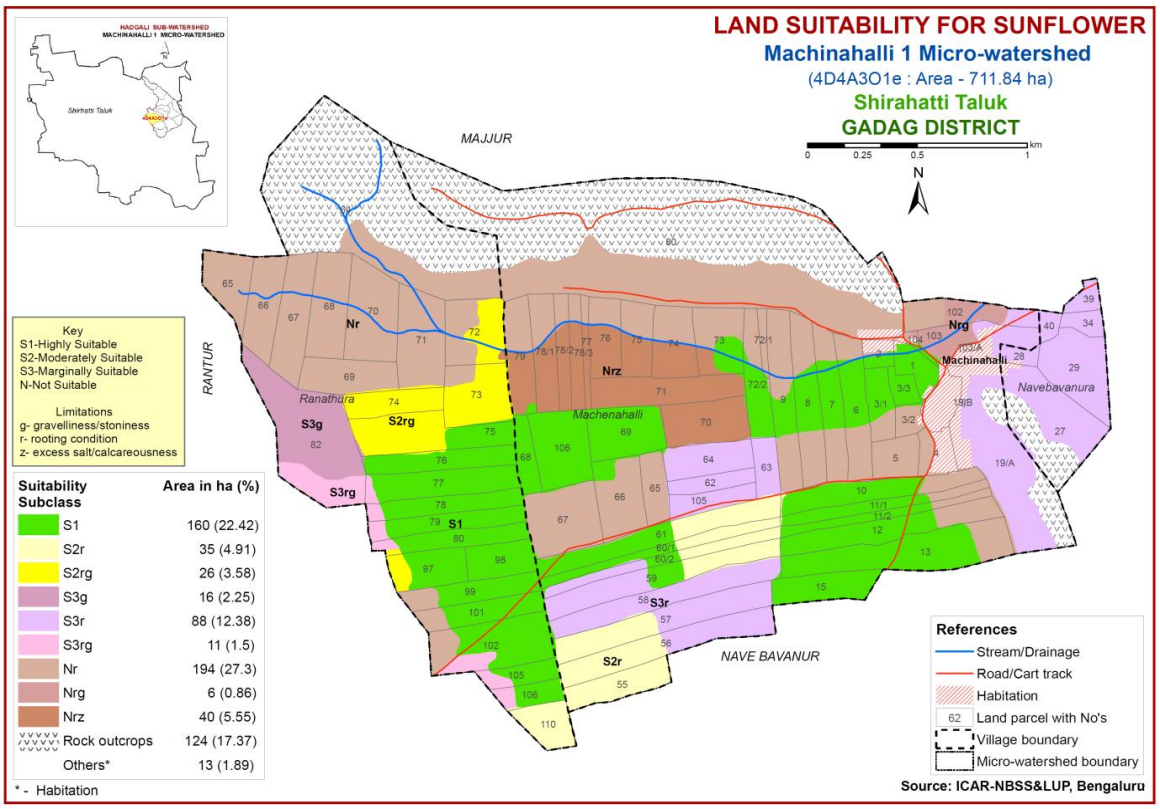


Fig. 7.4 Land Suitability map of Sunflower

7.5 Land Suitability for Onion (*Allium cepa*)

Onion is the most important vegetable crop grown in Raichur, Dharwad, Belgaum, Gulbarga, Bijapur, Bidar, Bellary, Chitradurga and Chamarajnagar districts. The crop requirements for growing onion (Table 7.6) were matched with the soil-site characteristics (Table 7.1) and a land suitability map for growing onion was generated. The area extent and their geographical distribution of different suitability subclasses in the microwatershed is given in Figure 7.5.

Table 7.6 Land suitability criteria for Onion

Crop requirement		Rating			
Soil –site characteristics	**Unit**	**Highly suitable (S1)**	**Moderately Suitable (S2)**	**Marginally suitable (S3)**	**Not suitable(N)**
Mean temperature in growing season	^{0}c	20-30	30-35	35-40	>40
Slope	%	<3	3-5	5-10	>10
Soil drainage	Class	Well drained	Moderately /imperfectly	Poor drained	Very poorly drained
Soil reaction	pH	6.5-7.3	7.3-7.8 5.0-5.4	7.8-8.4 <5.0	>8.4
Surface soil texture	Class	scl, sil, sl	sc, sicl, c (red soil)	sc, c (black soil)	ls
Soil depth	Cm	>75	50-75	25-50	<25
Gravel content	%vol.	<15	15-35	35-60	60-80
Salinity (ECe)	dsm^{-1}	<1.0	1.0-2.0	2.0-4.0	<4
Sodicity (ESP)	%	<5	5-10	10-15	>15

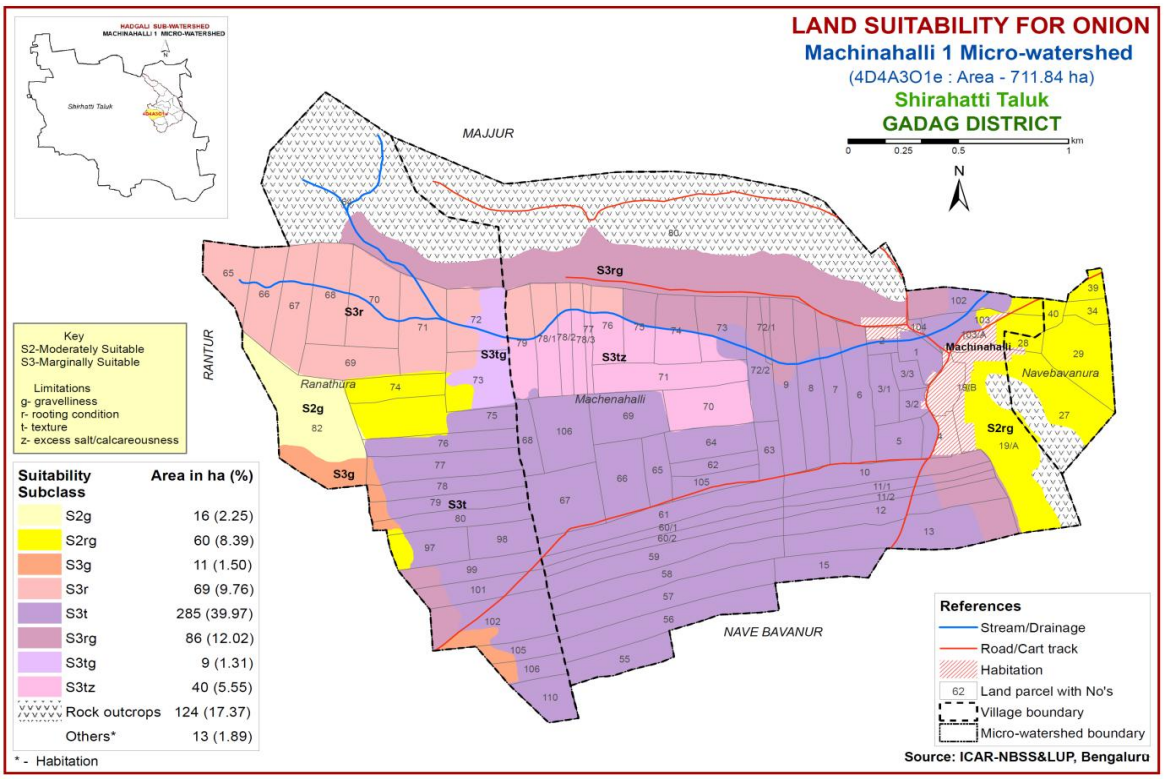


Fig. 7.5 Land Suitability map of Onion

There are no highly suitable (Class S1) land for growing onion. Moderately suitable (Class S2) lands occupy an area of about 76 ha (11%) for growing onion with minor limitations of gravelliness and rooting depth. They are distributed in the western and eastern part of the microwatershed. The marginally suitable (Class S3) lands cover major area of about 500 ha (70%) and occur in the western, central, southern and eastern part of the microwatershed. They have moderate limitations of gravelliness, rooting depth, texture and calcareousness.

7.6 Land Suitability for Groundnut (*Arachis hypogaea*)

Groundnut is one of the major oilseed crop grown in an area of 6.54 lakh ha in Karnataka in most of the districts either as rainfed or irrigated crop. The crop requirements for growing groundnut (Table 7.7) were matched with the soil-site characteristics (Table 7.1) of the soils of the microwatershed and a land suitability map for growing groundnut was generated. The area extent and their geographical distribution of different suitability subclasses in the microwatershed are given in Figure 7.6.

Table 7.7 Crop suitability criteria for Groundnut

Crop requirement		Rating			
Soil–site characteristics	**Unit**	**Highly suitable (S1)**	**Moderately Suitable (S2)**	**Marginally suitable (S3)**	**Not suitable (N)**
Slope	%	<3	3-5	5-10	>10
LGP	Days	100-125	90-105	75-90	
Soil drainage	Class	Well drained	Mod. Well drained	Imperfectly drained	Poorly drained
Soil reaction	pH	6.0-8.0	8.1-8.5, 5.5-5.9	>8.5, <5.5	
Surface soil texture	Class	l, cl, sil, sc, sicl	Sc, sic, c,	S, ls, sl c (>60%)	S, fragmental
Soil depth	Cm	>75	50-75	25-50	<25
Gravel content	%vol.	<35	35-50	>50	
$CaCO_3$ in root zone	%	high	Medium	low	
Salinity (EC)	dSm^{-1}	<2.0	2.0-4.0	4.0-8.0	
Sodicity (ESP)	%	<5	5-10	>10	

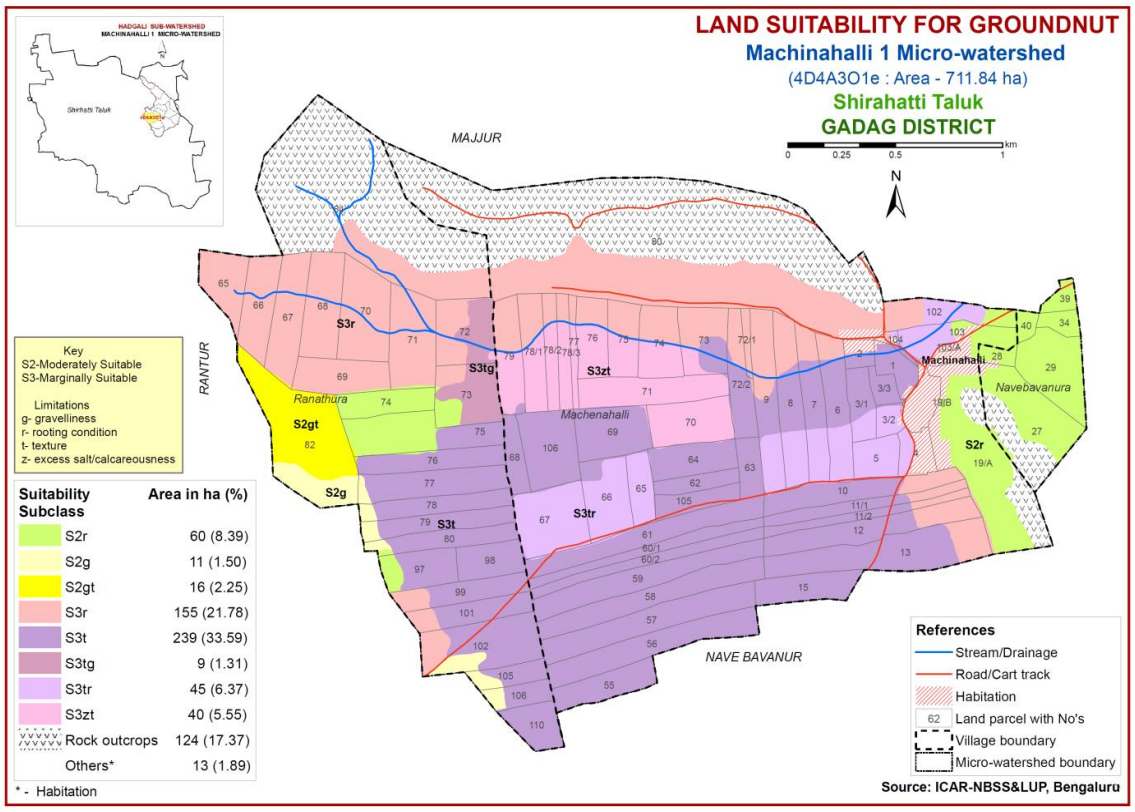


Fig. 7.6 Land Suitability map of Groundnut

There are no highly suitable (Class S1) lands for growing groundnut. Moderately suitable lands (Class S2) cover an area of about 87 ha (12%) and are distributed in the western and eastern part of the microwatershed. They have minor limitations of rooting depth, texture and gravelliness. Marginally suitable lands (Class S3) for growing groundnut occupy maximum area of about 488 ha (69%) and are distributed in the nothwestern, central, southern and eastern part of the microwatershed with moderate limitations of gravelliness, rooting depth, texture and calcareousness.

7.7 Land Suitability for Chilli (*Capsicum annuum L*)

Chilli is one of the major fruit and spice crop grown in an area of 0.42 lakh ha in Karnataka State. The crop requirements for growing chilli (Table 7.8) were matched with the soil-site characteristics (Table 7.1) of the soils of the microwatershed and a land suitability map for growing chilli was generated. The area extent and their geographic distribution of different suitability subclasses in the microwatershed are given in Figure 7.7.

Highly suitable (Class S1) lands are not found for growing chilli. Moderately suitable (Class S2) lands cover major area of about 410 ha (57%) and are distributed in the western, central, eastern and southern parts of the microwatershed. They have minor limitations of gravelliness, rooting depth and calcareousness. Marginally suitable (Class S3) lands for growing chilli occupy an area of about 166 ha (23%) and are distributed in the northwestern, central and southwestern part of the microwatershed and have moderate limitations of rooting depth and gravelliness.

Table 7.8 Crop suitability criteria for Chilli

Crop requirement		**Rating**			
Soil –site characteristics	**Unit**	**Highly suitable (S1)**	**Moderately suitable (S2)**	**Marginally suitable (S3)**	**Not suitable (N)**
Mean temperature in growing season	^{0}c	20-30	30-35 13-15	35-40 10-12	>40 <10
Slope	%	<3	3-5	5-10	>10
LGP	Days	>150	120-150	90-120	<90
Soil drainage	Class	Well drained	Moderately drained	Imp./poor/drained / excessively	Very poorly drained
Soil reaction	pH	6.5-7.8 6.0-7.0	7.8-8.4	8.4-9.0 5.0-5.9	>9.0
Surface soil texture	Class	scl, cl, sil	sl, sc, sic,c(m/k)	C(ss), ls, s	
Soil depth	Cm	>75	50-75	25-50	<25
Gravel content	%vol.	<15	15-35	35-60	>60
Salinity (ECe)	dsm^{-1}	<1.0	1.0-2.0	2.0-4.0	<4
Sodicity (ESP)	%	<5	5-10	10-15	

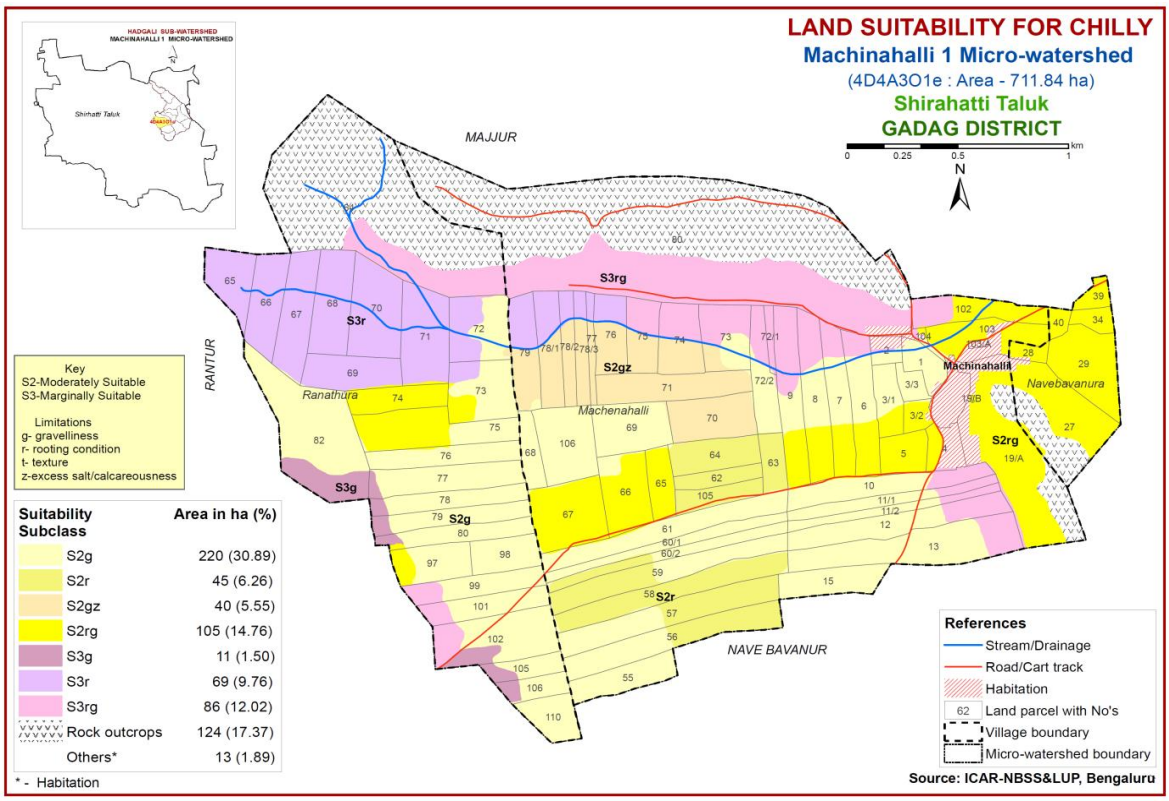


Fig. 7.7 Land Suitability map of chilli

7.8 Land Suitability for Sugarcane (*Saccharum officinarum*)

Sugarcane is the most important commercial crop grown in 6.7 lakh ha area in Kalaburgi, Bijapur, Bagalkot, Bidar, Mysore, Chamarajanagar and Mandya districts. The crop requirements for growing sugarcane (Table 7.9) were matched with the soil-site characteristics (Table 7.1) and a land suitability map for growing sugarcane was generated. The area extent and their geographical distribution of different suitability subclasses in the microwatershed is given in Figure 7.8.

Table 7.9 Land suitability criteria for Sugarcane

Crop requirement		Rating			
Soil–site characteristics	**Unit**	**Highly suitable (S1)**	**Moderately Suitable (S2)**	**Marginally suitable (S3)**	**Not suitable (N)**
Slope	%	<3	3-5	5-8	>8
Soil drainage	Class	Well drained	Mod./imperfectly drained	Poorly drained	V.poor/excessively drained
Soil reaction	pH	7.0-8.0	6.0-6.9 8.1-9.0	4.0-5.9 9.1-9.5	<4.0/ >9.5
Surface soil texture	Class	l, cl, sil, sicl	C(m/k), sl	C+(ss)	
Soil depth	Cm	>100	100-75	75-50	<50
stoniness	%	<15	15-35	35-50	>50
Salinity (EC)	dSm^{-1}	<2.0	2.0-4.0	4.0-9.0	>9
Sodicity (ESP)	%	<10	10-15	15-25	>25

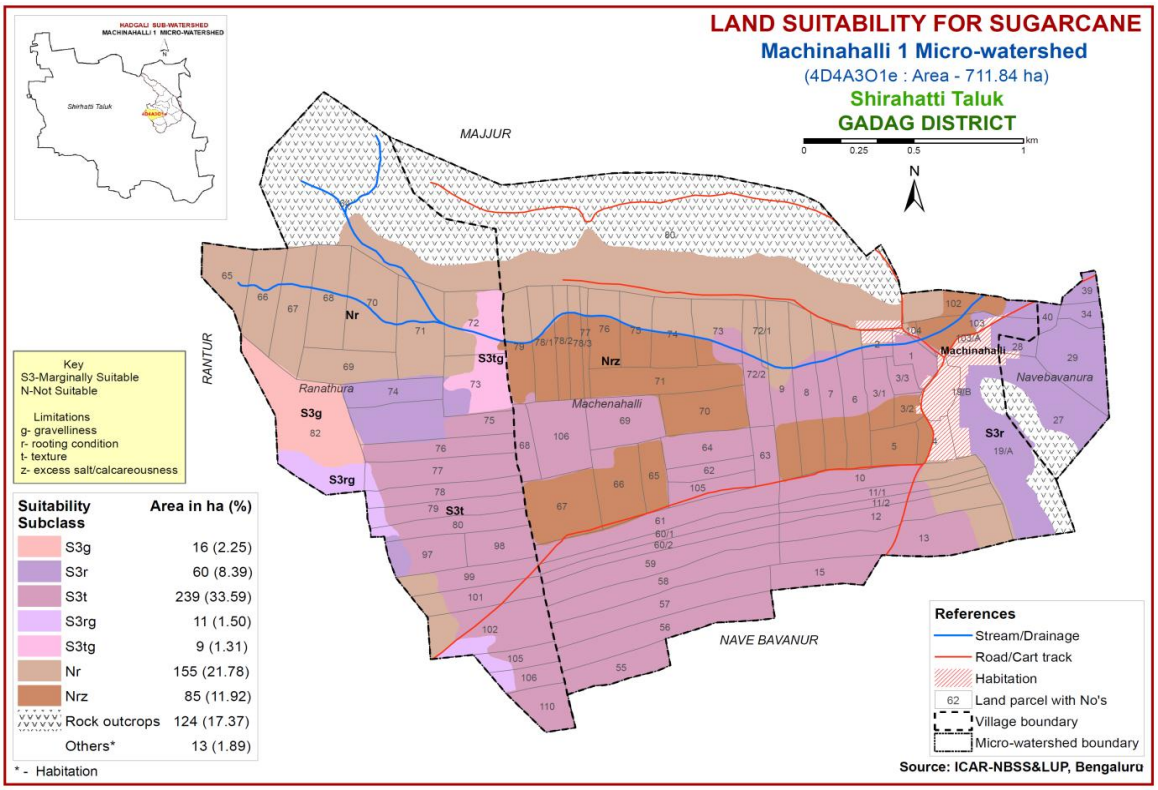


Fig. 7.8 Land Suitability map of Sugarcane

There are no highly suitable (Class S1) and moderately suitable (Class S2) lands for growing sugarcane. Marginally suitable (Class S3) lands cover major area of about 335 ha (47%) and occur in the western, central, southern and eastern part of the microwatershed. They have moderate limitations of gravelliness, rooting depth and texture. An area of about 240 ha (34%) is not suitable (Class N) for growing sugarcane and occur in the northwestern, central, southeastern and small patch in the southwestern part of the microwatershed and have severe limitations of rooting depth and calcareousness.

7.9 Land Suitability for Pomegranate (*Punica granatum*)

Pomegranate is one of the commercially grown fruit crop in Karnataka in an area of 0.18 lakh ha mainly in Bijapur, Bagalkot, Koppal, Gadag and Chitradurga districts. The crop requirements for growing pomegranate (Table 7.10) were matched with the soil-site characteristics (Table 7.1) of the soils of the microwatershed and a land suitability map for growing pomegranate was generated. The area extent and their geographic distribution of different suitability subclasses in the microwatershed are given in Figure 7.9.

There are no highly suitable (Class S1) lands for growing pomegranate. Maximum area of about 264 ha (37%) is moderately suitable (Class S2) for growing pomegranate and occur in the western, southern and central part of the microwatershed. They have minor limitations of texture, rooting depth and gravelliness. Marginally suitable (Class S3) lands for growing pomegranate occupy an area of about 71 ha (10%) and are distributed in the southwestern, central and eastern part of the microwatershed with minor limitations of rooting depth and gravelliness. An area of about 240 ha (34%) is not suitable (Class N) for growing pomegranate and occur in northwestern, central,

northeastern and small patches in the southwestern part of the microwatershed and have very severe limitations of rooting depth, texture and calcareousness.

Table 7.10 Crop suitability criteria for Pomegranate

Crop requirement			Rating			
Soil –site characteristics		Unit	Highly suitable (S1)	Moderately Suitable(S2)	Marginally suitable(S3)	Not suitable(N)
Climate	Temperature in growing season	^{0}C	30-34	35-38 25-29	39-40 15-24	
Soil moisture	Growing period	Days	>150	120-150	90-120	<90
Soil aeration	Soil drainage	Class	Well drained	imperfectly drained		
Nutrient availability	Texture	Class	Sl, scl, l, cl	C, sic, sicl	Cl, s, ls	S, fragmental
Rooting conditions	pH	1:2.5	5.5-7.5	7.6-8.5	8.6-9.0	
	Soil depth	Cm	>100	75-100	50-75	<50
	Gravel content	% vol.	nil	15-35	35-60	>60
Soil toxicity	Salinity	dS/m	Nil	<9	>9	<50
	Sodicity	%	nil			
Erosion	Slope	%	<3	3-5	5-10	

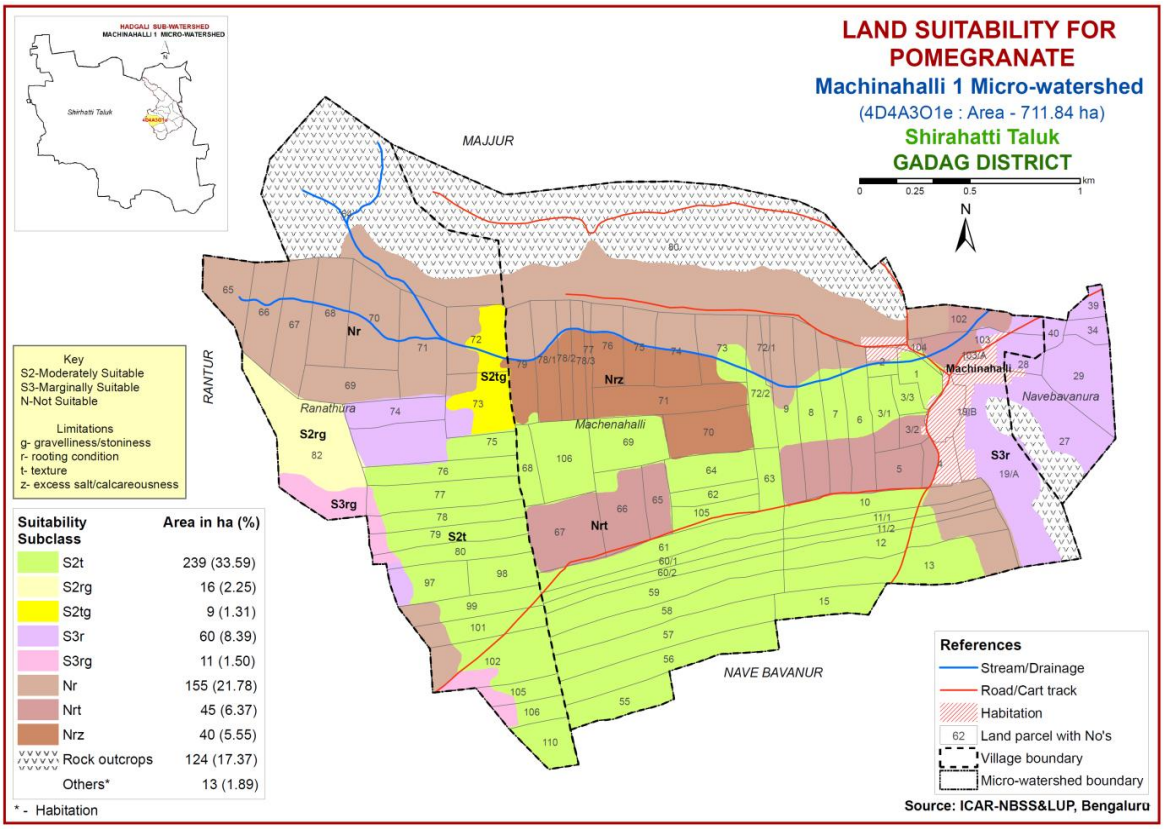


Fig. 7.9 Land Suitability map of Pomegranate

7.10 Land suitability for Tomato (*Solanum lycopersicum*)

Tomato is the most important fruit crop grown in an area of 0.65 lakh ha in almost all the districts of the State. The crop requirements (Table 7.11) for growing tomato were matched with the soil-site characteristics (Table 7.1) and a land suitability map for growing tomato was generated. The area extent and their geographic distribution of different suitability subclasses in the microwatershed are given in Figure 7.10.

There are no highly suitable (Class S1) lands for growing tomato. Moderately suitable (Class S2) lands occupy maximum area of about 410 ha (57%) and occur in the western, central, southeastern and eastern part of the microwatershed. They have minor limitations of gravelliness, rooting depth, texture and calcareousness. The marginally suitable (Class S3) lands cover an area of about 166 ha (23%) and are distributed in the northwestern, southwestern, central and southeastern part of the microwatershed with moderate limitations of rooting depth and gravelliness.

Table 7.11 Crop suitability criteria for Tomato

Crop requirement			**Rating**			
Soil –site characteristics		**Unit**	**Highly suitable (S1)**	**Moderately suitable(S2)**	**Marginally suitable (S3)**	**Not suitable (N)**
climate	Temperature in growing season	^{0}c	25-28	29-32 20-24	15-19 33-36	<15 >36
Soil moisture	Growing period	Days	>150	120-150	90-120	
Soil aeration	Soil drainage	Class	Well drained	Mod. well drained	Imperfectly drained	Poorly drained
Nutrient availability	Texture	Class	l, sl, cl, scl	Sic, sicl, sc, c(m/k)	C (ss)	ls, s
	pH	1:2.5	6.0-7.0	5.0-5.9 7.1-8.5	<5; >8.5	
	$CaCO_3$ in root zone	%	Non calcareous	Slightly calcareous	Strongly calcareous	
Rooting conditions	Soil depth	Cm	>75	50-75	25-50	<25
	Gravel content	% vol.	<15	15-35	>35	
Soil toxicity	Salinity	ds/m	Non saline	slight	strongly	
	Sodicity (ESP)	%	<10	10-15	>15	-
Erosion	Slope	%	1-3	3-5	5-10	>10

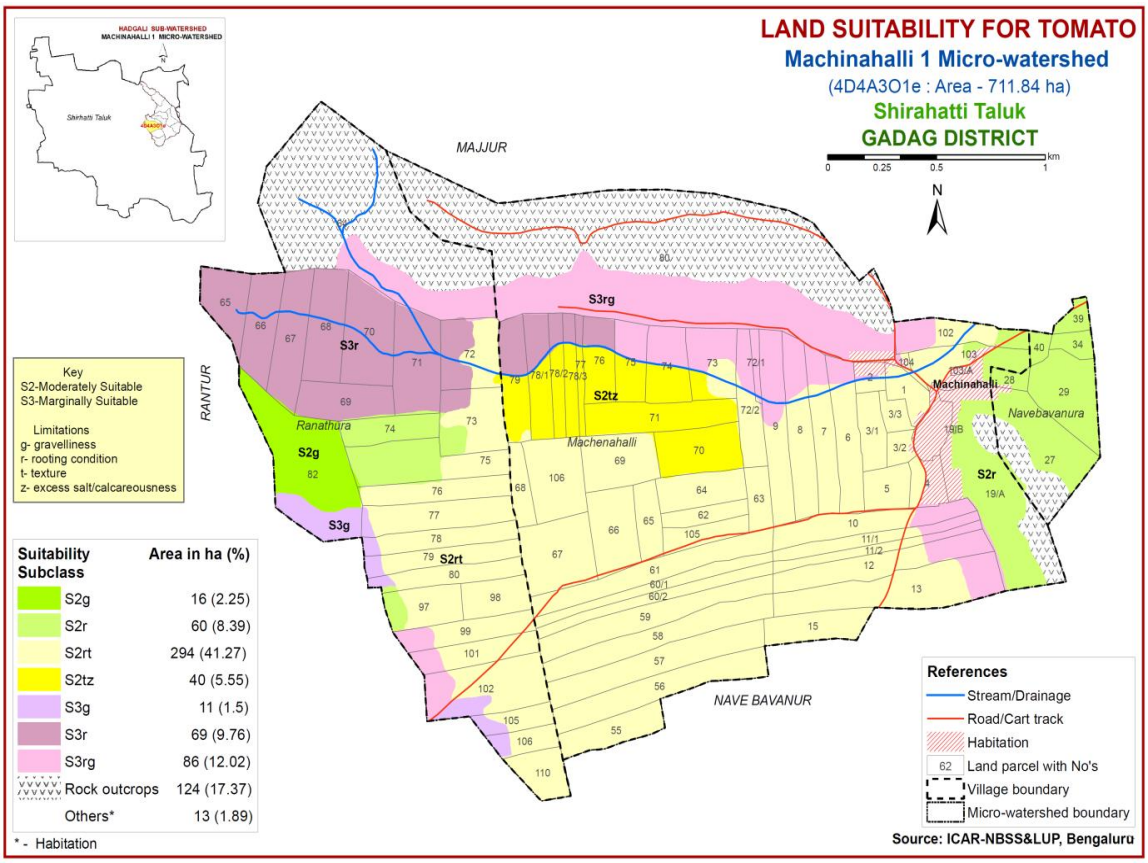


Fig. 7.10 Land Suitability map of Tomato

7.11 Land suitability for Guava (*Psidium guajava*)

Guava is the most important fruit crop grown in an area of 6558 ha in almost all the districts of the State. The crop requirements (Table 7.12) for growing guava were matched with the soil-site characteristics (7.1) and a land suitability map for growing guava was generated. The area extent and their geographic distribution of different suitability subclasses in the microwatershed are given in Figure 7.11.

Moderately suitable (Class S2) lands occupy a very small area of about 16 ha (2%) and occur in the western part of the microwatershed with minor limitation of gravelliness. The marginally suitable (Class S3) lands cover maximum area of about 319 ha (45%) and are distributed in the southwestern, central, southern and eastern part of the microwatershed. They have moderate limitations of rooting depth, texture and gravelliness. An area of about 240 ha (34%) is not suitable (Class N) for growing guava and are distributed in the northwestern, central and southwestern part of the microwatershed with severe limitations of rooting depth and texture.

Table 7.12 Crop suitability criteria for Guava

Crop requirement			Rating			
Soil –site characteristics		**Unit**	**Highly suitable(S1)**	**Moderately suitable (S2)**	**Marginally suitable(S3)**	**Not suitable (N)**
Climate	Temperature in growing season	^{0}C	28-32	33-36 24-27	37-42 20-23	
Soil moisture	Growing period	Days	>150	120-150	90-120	<90
Soil aeration	Soil drainage	Class	Well drained	Mod. to imperfectly	poor	Very poor
Nutrient availability	Texture	Class	Scl, l, cl, sil	Sl,sicl,sic.,sc,c	C (<60%)	C (>60%)
	pH	1:2.5	6.0-7.5	7.6-8.0:5.0-5.9	8.1-8.5:4.5-4.9	>8.5:<4.5
	$CaCO_3$ in root zone	%	Non calcareous	<10	10-15	>15
Rooting conditions	Soil depth	Cm	>100	75-100	50-75	<50
	Gravel content	% vol.	<15	15-35	>35	
Soil toxicity	Salinity	dS/m	<2.0	2.0-4.0	4.0-6.0	
	Sodicity	%	Non sodic	10-15	15-25	>25
Erosion	Slope	%	<3	3-5	5-10	>10

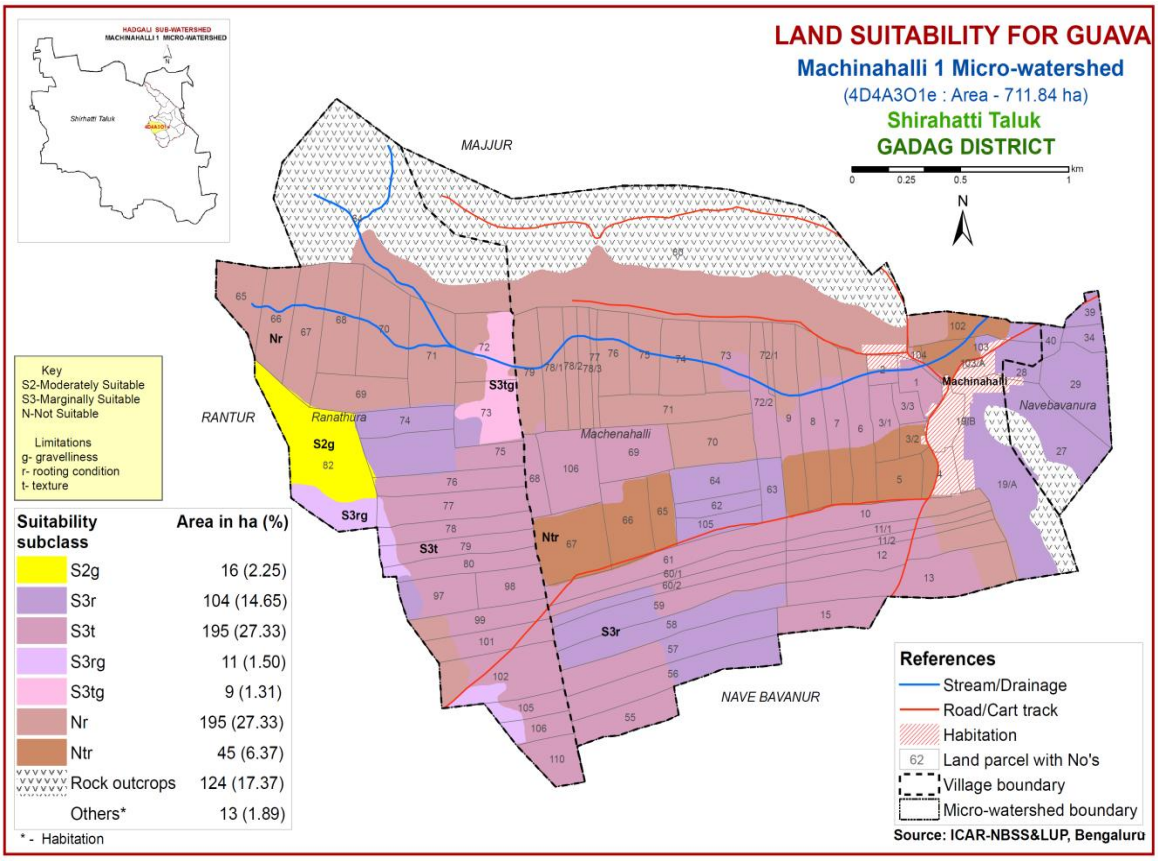


Fig. 7.11 Land Suitability map of Guava

7.12 Land suitability for Mango (*Mangifera indica*)

Mango is the most important fruit crop grown in about 1.73 lakh ha in almost all the districts of the State. The crop requirements (Table 7.13) for growing mango were matched with the soil-site characteristics (Table 7.1) and a land suitability map for growing mango was generated. The area extent and their geographic distribution of different suitability subclasses in the microwatershed are given in Figure 7.12.

A very small area of about 16 ha (2%) is moderately suitable (Class S2) for growing mango and occur in the western part of the microwatershed. They have minor limitations of gravelliness and rooting depth. Maximum area of about 559 ha (78%) is not suitable (Class N) for growing mango and occur in major part of the microwatershed.

Table 7.13 Crop suitability criteria for Mango

Crop requirement			**Rating**			
Soil-site characteristics		**Unit**	**Highly suitable (S1)**	**Moderately suitable (S2)**	**Marginally suitable (S3)**	**Not Suitable (N)**
Climate	Temp. in growing season	^{0}C	28-32	24-27 33-35	36-40	20-24
	Min. temp. before flowering	^{0}C	10-15	15-22	>22	
Soil moisture	Growing period	Days	>180	150-180	120-150	<120
Soil aeration	Soil drainage	Class	Well drained	Mod. To imperfectly drained	Poor drained	Very poorly drained
	Water table	M	>3	2.50-3.0	2.5-1.5	<1.5
Nutrient availability	Texture	Class	Sc, l, sil, cl	Sl, sc, sic, l,c	C (<60%)	C (>60%),
	pH	1:2.5	5.5-7.5	7.6-8.55.0-5.4	8.6-9.04.0-4.9	>9.0<4.0
	OC	%	High	medium	low	
	$CaCO_3$ in root zone	%	Non calcareous	<5	5-10	>10
Rooting conditions	Soil depth	cm	>200	125-200	75-125	<75
	Gravel content	%vol	Non-gravelly	<15	15-35	>35
Soil toxicity	Salinity	dS/m	Non saline	<2.0	2.0-3.0	>3.0
	Sodicity	%	Non sodic	<10	10-15	>15
Erosion	Slope	%	<3	3-5	5-10	

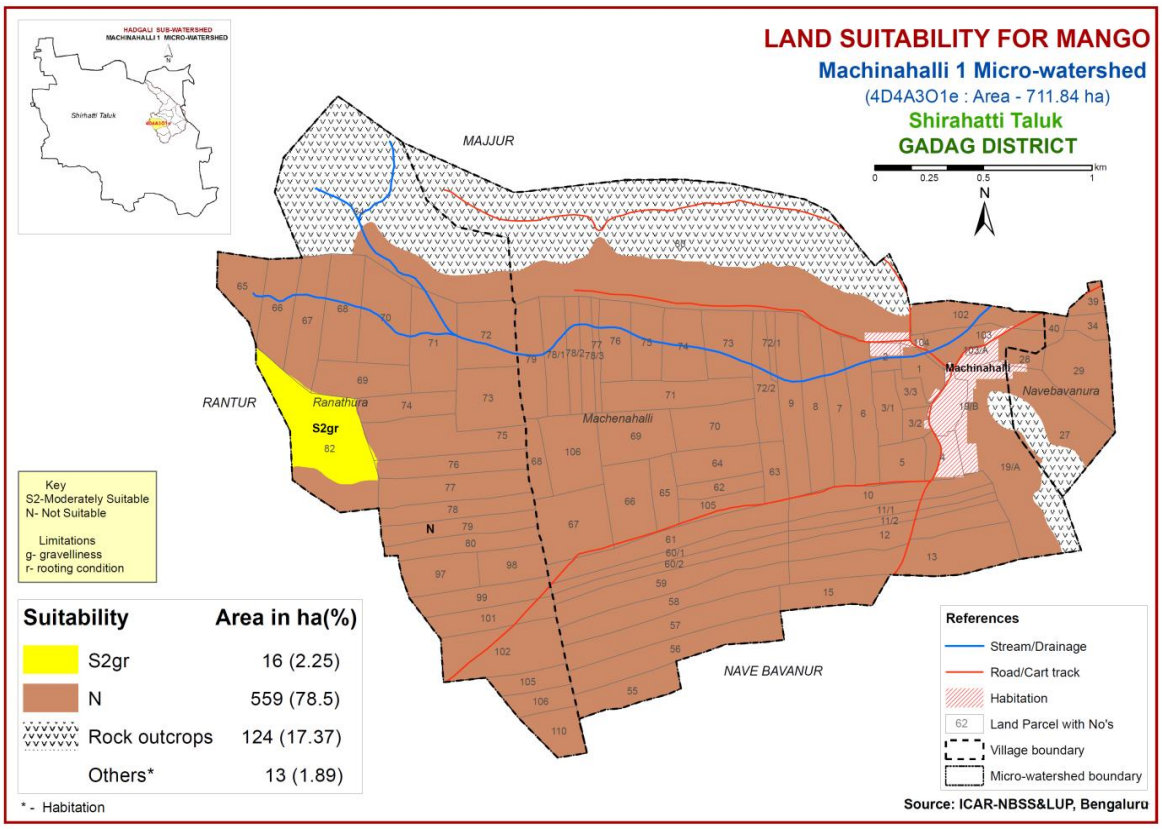


Fig. 7.12 Land Suitability map of Mango

7.13 Land suitability for Sapota (*Manilkara zapota*)

Sapota is the most important fruit crop grown in an area of 29373 ha in almost all the districts of the State. The crop requirements (Table 7.14) for growing sapota were matched with the soil-site characteristics (Table 7.1) and a land suitability map for growing sapota was generated. The area extent and their geographical distribution of different suitability subclasses in the microwatershed is given in Figure 7.13.

There are no highly suitable (Class S1) lands for growing sapota. An area of about 16 ha (2%) is moderately suitable (Class 2) and occur in the western part of the microwatershed. They have minor limitation of gravelliness. The marginally suitable (Class S3) lands cover major area of about 320 ha (45%) and are distributed in the central, southern and eastern part of the microwatershed. They have moderate limitations of rooting depth, texture and gravelliness. An area of about 240 ha (34%) is not suitable for growing sapota and are distributed in the northwestern, central, southwestern, northeastern and southeastern part of the microwatershed and have severe limitations of rooting depth and texture.

Table 7.14 Crop suitability criteria for Sapota

Crop requirement			Rating			
Soil –site characteristics		**Unit**	**Highly suitable (S1)**	**Moderately suitable (S2)**	**Marginally suitable(S3)**	**Not suitable (N)**
Climate	Temperature in growing season	^{0} C	28-32	33-36 24-27	37-42 20-23	>42 <18
Soil moisture	Growing period	Days	>150	120-150	90-120	<120
Soil aeration	Soil drainage	Class	Well drained	Moderately well drained	Imperfectly drained	Poorly drained
Nutrient availability	Texture	Class	Scl, l, cl, sil	Sl, sicl, sc	C (<60%)	ls, s, C (>60%)
	pH	1:2.5	6.0-7.5	7.6-8.0 5.0-5.9	8.1-9.0 4.5-4.9	>9.0 <4.5
	$CaCO_3$ in root zone	%	Non calcareous	<10	10-15	>15
Rooting conditions	Soil depth	Cm	>150	75-150	50-75	<50
	Gravel content	% vol.	Non gravelly	<15	15-35	<35
Soil toxicity	Salinity	dS/m	Non saline	Up to 1.0	1.0-2.0	2.0-4.0
	Sodicity	%	Non sodic	10-15	15-25	>25
Erosion	Slope	%	<3	3-5	5-10	>10

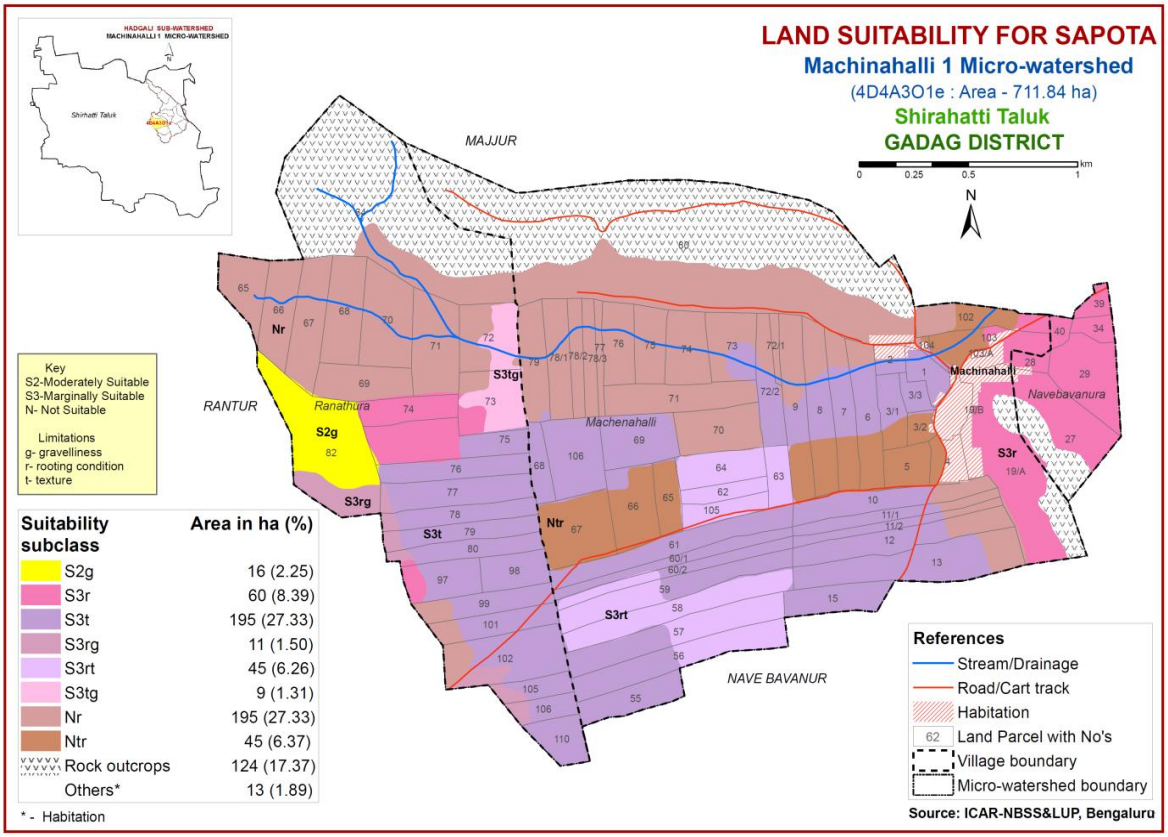


Fig. 7.13 Land Suitability map of Sapota

7.14 Land Suitability for Jackfruit (*Artocarpus heterophyllus*)

Jackfruit is the most important fruit crop grown in 5368 ha in all the districts of the state. The crop requirements for growing jackfruit were matched with the soil-site characteristics and a land suitability map for growing jackfruit was generated. The area extent and their geographical distribution of different suitability subclasses in the microwatershed is given in Figure 7.14.

There are no highly suitable (Class S1) and marginally suitable (Class S3) lands for growing jackfruit. Moderately suitable (S2) lands occupy an area of about 16 ha (2%) and are distributed in the western part of the microwatershed. They have minor limitations of gravelliness and rooting depth. Maximum area of about 559 ha (78%) is not suitable (Class N) for growing jackfruit and occur in all parts of the microwatershed.

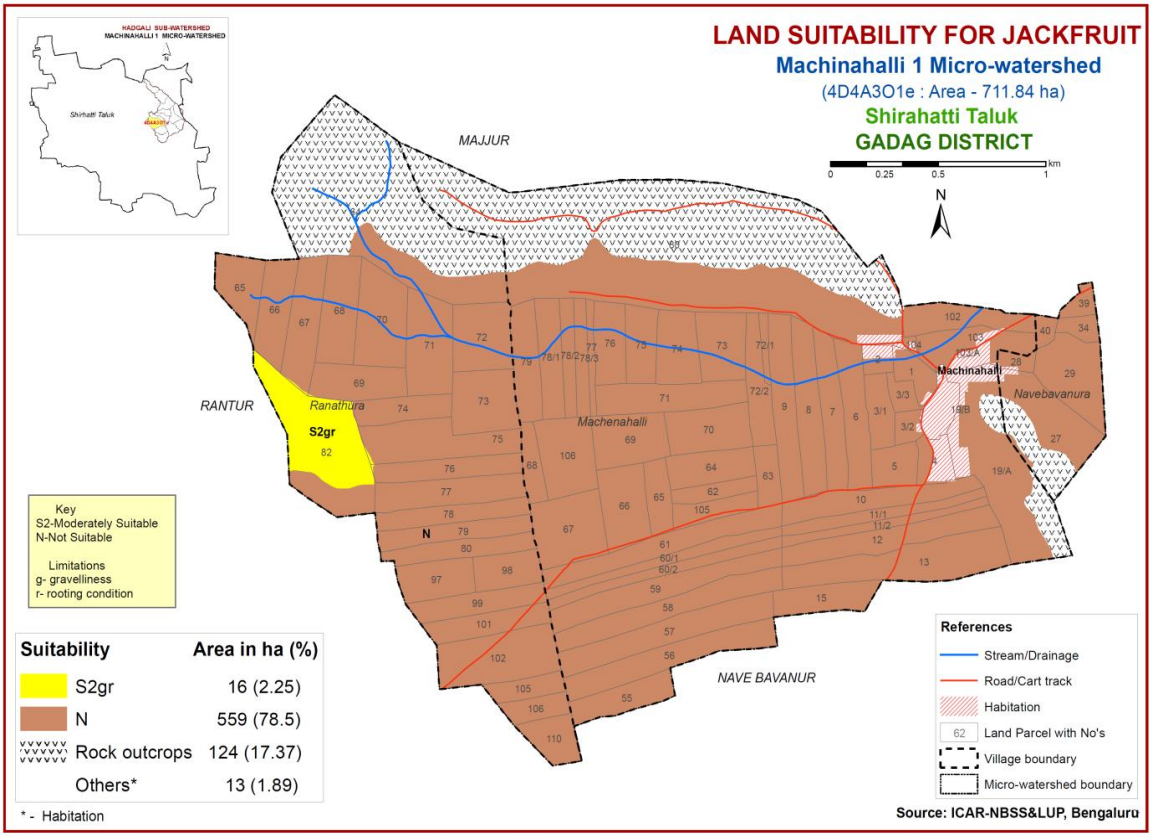


Fig. 7.14 Land Suitability map of Jackfruit

7.15 Land Suitability for Jamun (*Syzygium cumini*)

Jamun is an important fruit crop grown in almost all the districts of the State. The crop requirements for growing jamun were matched with the soil-site characteristics and a land suitability map for growing jamun was generated. The area extent and their geographical distribution of different suitability subclasses in the microwatershed is given in Figure 7.15.

There are no highly suitable (Class S1) lands for growing jamun in Machinahalli-1 microwatershed. Moderately suitable (S2) lands occupy a very small area of about 16 ha (2%) and are distributed in the western part of the microwatershed with minor limitations

of gravelliness and rooting depth. Major area of about 320 ha (45%) is marginally suitable (Class S3) and are distributed in the southern, central, southwestern and eastern part of the microwatershed. They have moderate limitations of rooting depth, texture and gravelliness. An area of about 240 ha (34%) is not suitable (Class N) and are distributed in the northwestern, central, northeastern and southeastern part of the microwatershed.

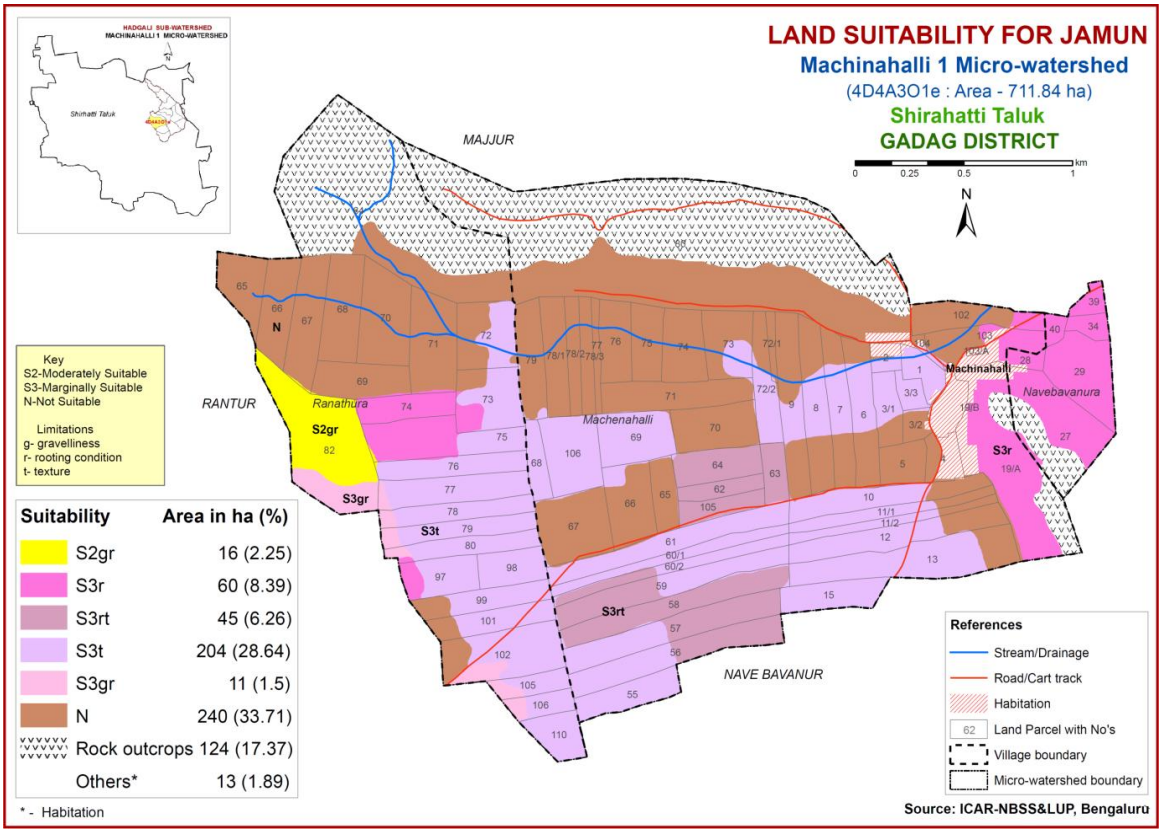


Fig. 7.15 Land Suitability map of Jamun

7.16 Land Suitability for Musambi (*Citrus limetta*)

Musambi is the most important fruit crop grown in an area of 5446 ha in almost all the districts of the state. The crop requirements for growing musambi were matched with the soil-site characteristics and a land suitability map for growing musambi was generated. The area extent and their geographical distribution of different suitability subclasses in the microwatershed is given in Figure 7.16.

There are no highly suitable lands for growing musambi. Moderately suitable (S2) lands occupy an area of about 176 ha (25%) and is distributed in the western, central, southeastern part of the microwatershed. They have minor limitations of gravelliness and rooting depth. An area of about 44 ha (6%) is marginally suitable (Class S3) for growing musambi and are distributed in the southern and central part of the microwatershed. They have moderate limitation of rooting depth. Major area of about 355 ha (50%) is not suitable (Class N) for growing musambi and are distributed in the northwestern, central, southwestern and eastern part of the microwatershed.

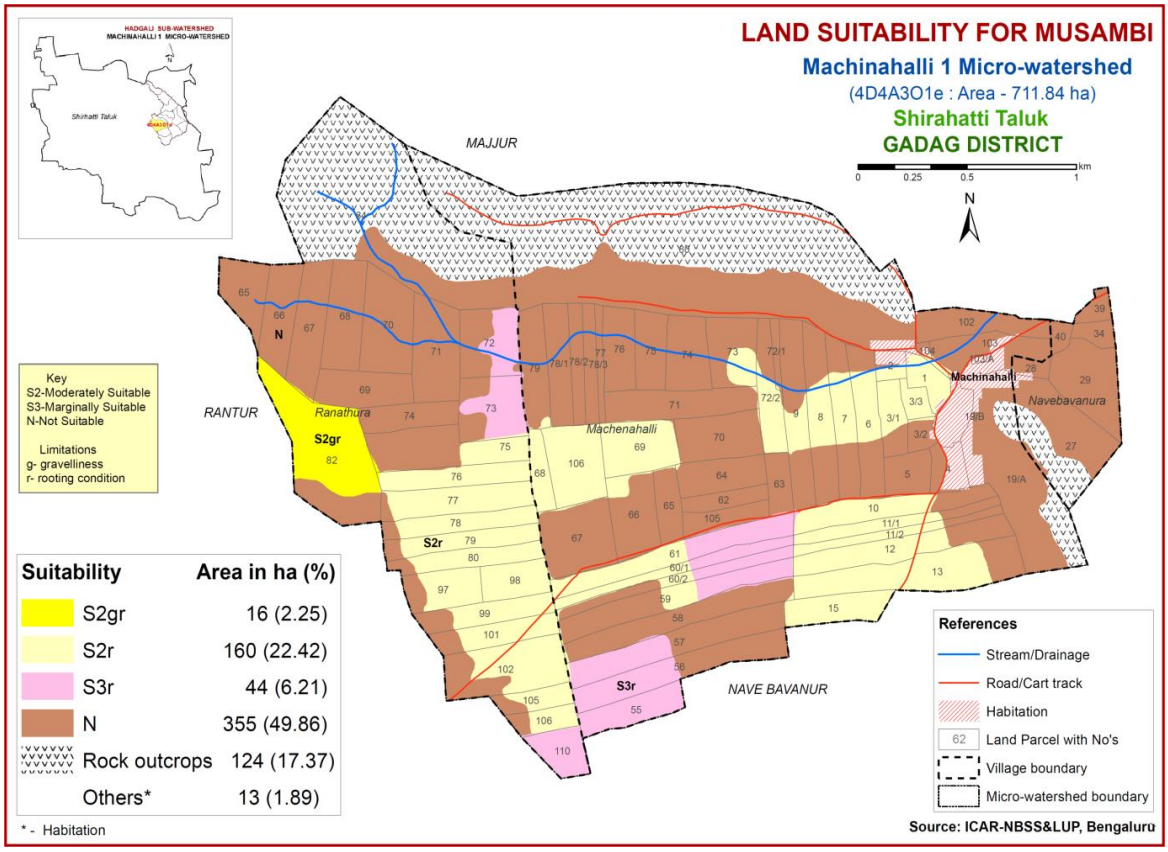


Fig. 7.16 Land Suitability map of Musambi

7.17 Land Suitability for Lime (*Citrus sp*)

Lime is one of the most important fruit crop grown in an area of 0.11 lakh ha in almost all the districts of the State. The crop requirements for growing lime (Table 7.15) were matched with the soil-site characteristics (Table 7.1) and a land suitability map for growing lime was generated (Fig. 7.17).

There are no highly suitable lands for growing lime. Moderately suitable (S2) lands occupy an area of about 176 ha (25%) and distributed in the western, central and southeastern part of the microwatershed. They have minor limitations of gravelliness and rooting depth. An area of about 44 ha (6%) is marginally suitable (Class S3) for growing musambi and are distributed in the southern and central part of the microwatershed with moderate limitation of rooting depth. Major area of about 355 ha (50%) is not suitable (Class N) for growing lime and are distributed in the northwestern, central, southwestern and eastern part of the microwatershed.

Table 7.15 Crop suitability criteria for Lime

Crop requirement			Rating			
Soil –site characteristics		**Unit**	**Highly suitable (S1)**	**Moderately suitable (S2)**	**Marginally suitable (S3)**	**Not suitable (N)**
Climate	Temperature in growing season	^{0}C	28-30	31-35 24-27	36-40 20-23	>40 <20
Soil moisture	Growing period	Days	240-265	180-240	150-180	<150
Soil aeration	Soil drainage	Class	Well drained	Mod. to imperfectly drained	Poorly	Very poorly
Nutrient availability	Texture	Class	Scl, l, sicl, cl, s	Sc, sc, c	C(>70%)	S, ls
	pH	1:2.5	6.0-7.5	5.5-6.47.6-8.0	4.0-5.4 8.1-8.5	<4.0 >8.5
	$CaCO_3$ in root zone	%	Non calcareous	Upto 5	5-10	>10
Rooting conditions	Soil depth	Cm	>150	100-150	50-100	<50
	Gravel content	% vol.	Non gravelly	15-35	35-55	>55
Soil toxicity	Salinity	dS/m	Non saline	Upto 1.0	1.0-2.5	>2.5
	Sodicity	%	Non sodic	5-10	10-15	>15
Erosion	Slope	%	<3	3-5	5-10	

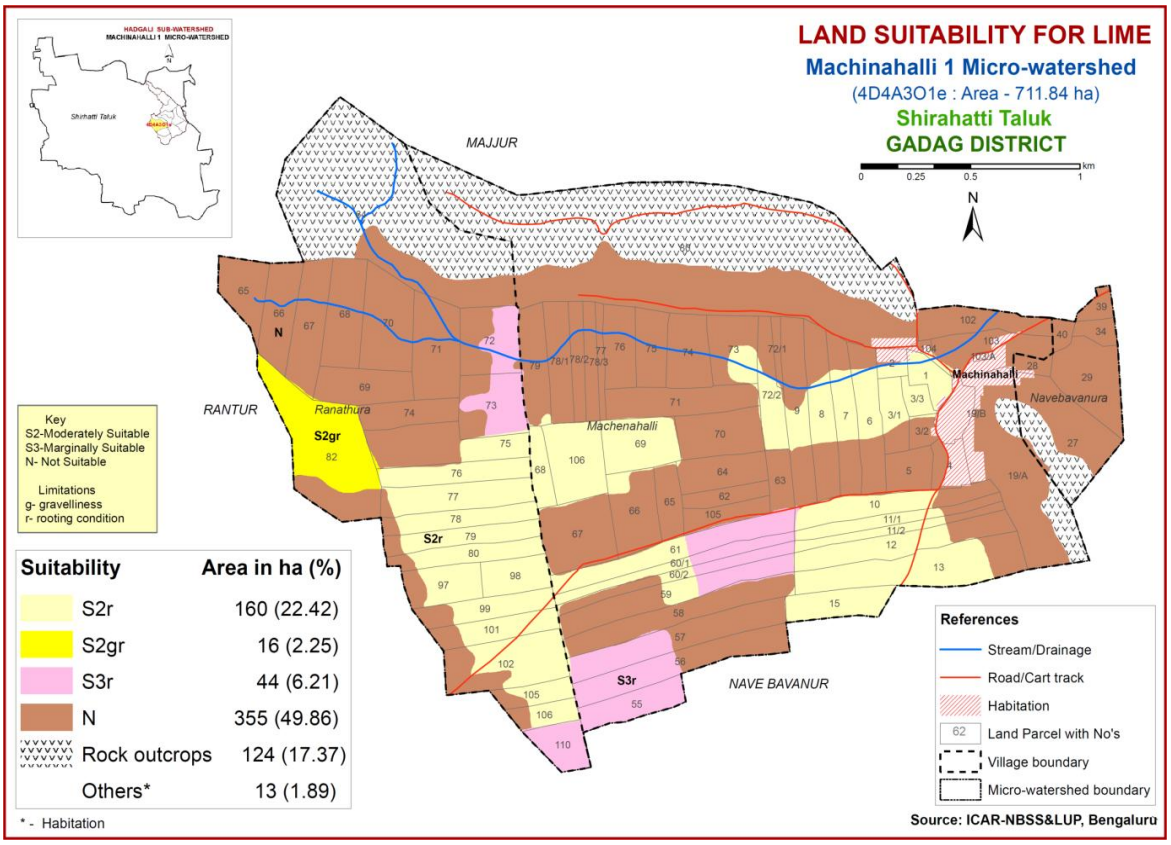


Fig. 7.17 Land Suitability map of Lime

7.18 Land Suitability for Cashew (*Anacardium occidentale)*

Cashew is one of the most important fruit and nut crop grown in an area of 1.24 lakh ha in almost all the districts of the State. The crop requirements for growing cashew were matched with the soil-site characteristics (Table 7.1) and a land suitability map for growing cashew was generated (Fig. 7.18).

Moderately suitable (S2) lands occupy an area of about 16 ha (2%) and are distributed in the western part of the microwatershed. They have minor limitations of gravelliness and rooting depth. An area of about 71 ha (10%) is marginally suitable (Class S3) for growing cashew and are distributed in the southwestern and eastern part of the microwatershed with moderate limitations of rooting depth and gravelliness. Major area of about 488 ha (69%) is not suitable (Class N) for growing cashew and are distributed in the western, central and southern part of the microwatershed.

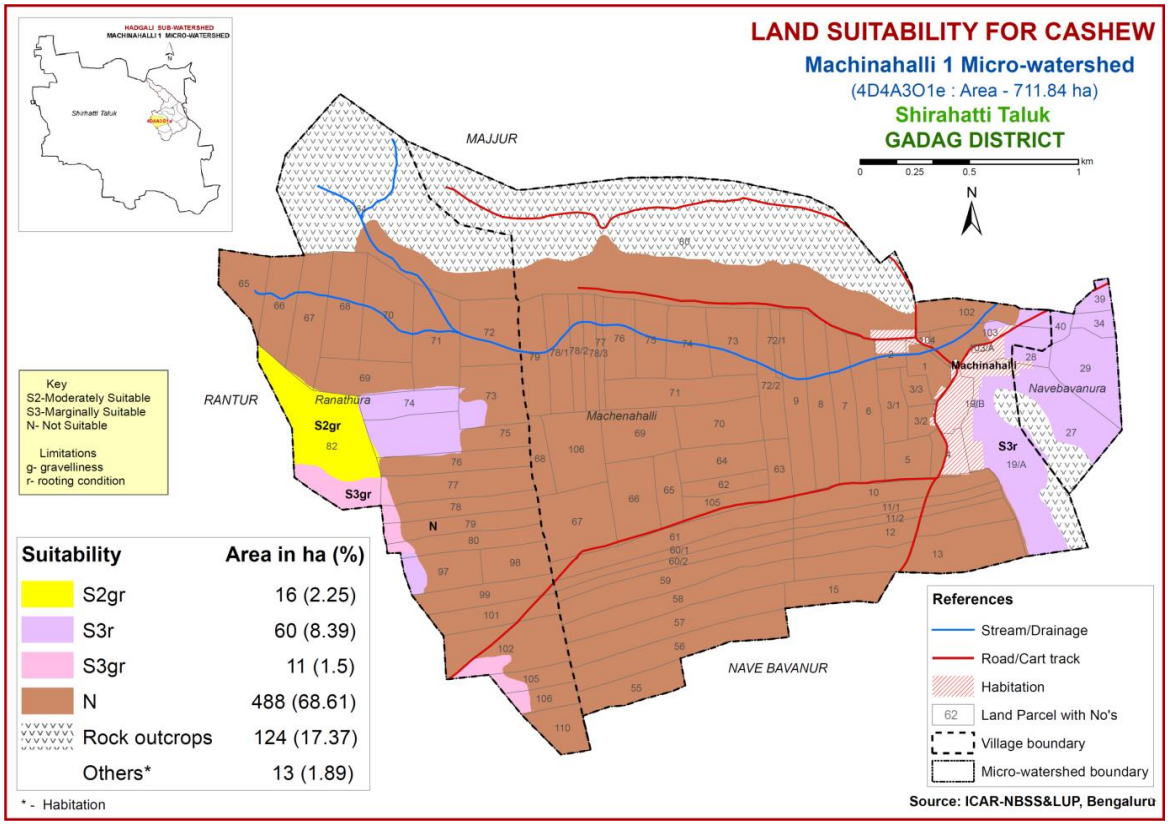


Fig. 7.18 Land Suitability map of Cashew

7.19 Land Suitability for Custard Apple (*Annona reticulata*)

Custard apple is one of the most important fruit crop grown in almost all the districts of the State. The crop requirements for growing custard apple were matched with the soil-site characteristics (Table 7.1) and a land suitability map for growing custard apple was generated. The area extent and their geographical distribution of different suitability subclasses in the microwatershed is given in Figure 7.19.

An area of 160 ha (22%) is highly suitable (Class S1) for growing custard apple and occur in the central and southeastern part of the microwatershed. Moderately suitable (Class S2) lands occupy an area of about 176 ha (25%) and occur in the western, southern and eastern part of the microwatershed. They have minor limitations of rooting depth and gravelliness. Major area of about 240 ha (34%) is marginally suitable (Class S3) for growing custard apple and are distributed in the northwestern and central part of the microwatershed with moderate limitation of rooting depth.

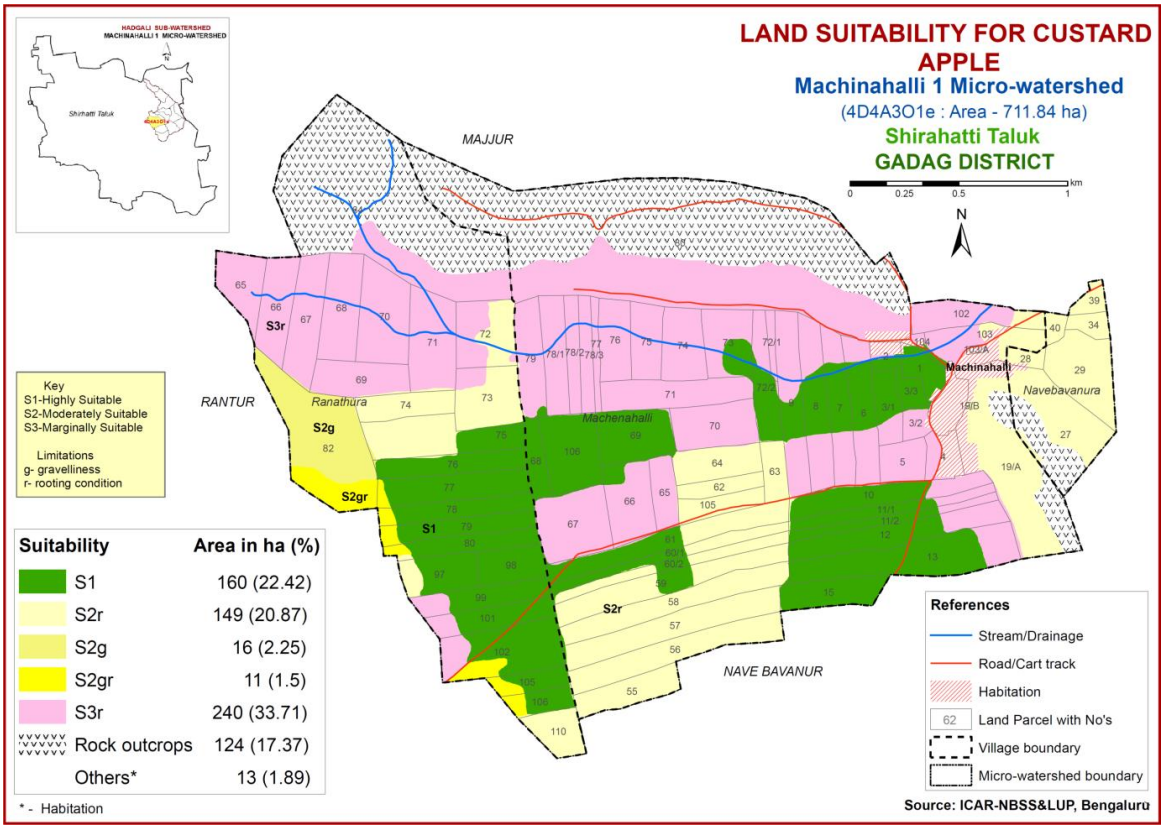


Fig. 7.19 Land Suitability map of Custard Apple

7.20 Land Suitability for Amla (*Phyllanthus emblica*)

Amla is one of the most important medicinal fruit plant grown in 151 ha in all the districts of the State. The crop requirements for growing amla were matched with the soil-site characteristics and a land suitability map for growing amla was generated. The area extent and their geographical distribution of different suitability subclasses in the microwatershed is given in Figure 7.20.

Highly suitable (Class S1) lands occupy an area of about 160 ha (22%) and are distributed in the central and southeastern part of the microwatershed. An area of about 159 ha (22%) is moderately suitable (Class S2) and occur in the western, central, southern and eastern part of the microwatershed. They have minor limitations of rooting depth and gravelliness. Major area of about 256 ha (36%) is marginally suitable (Class S3) for

growing custard apple and are distributed in the southwestern, central, northeastern and southeastern part of the microwatershed with moderate limitation of rooting depth.

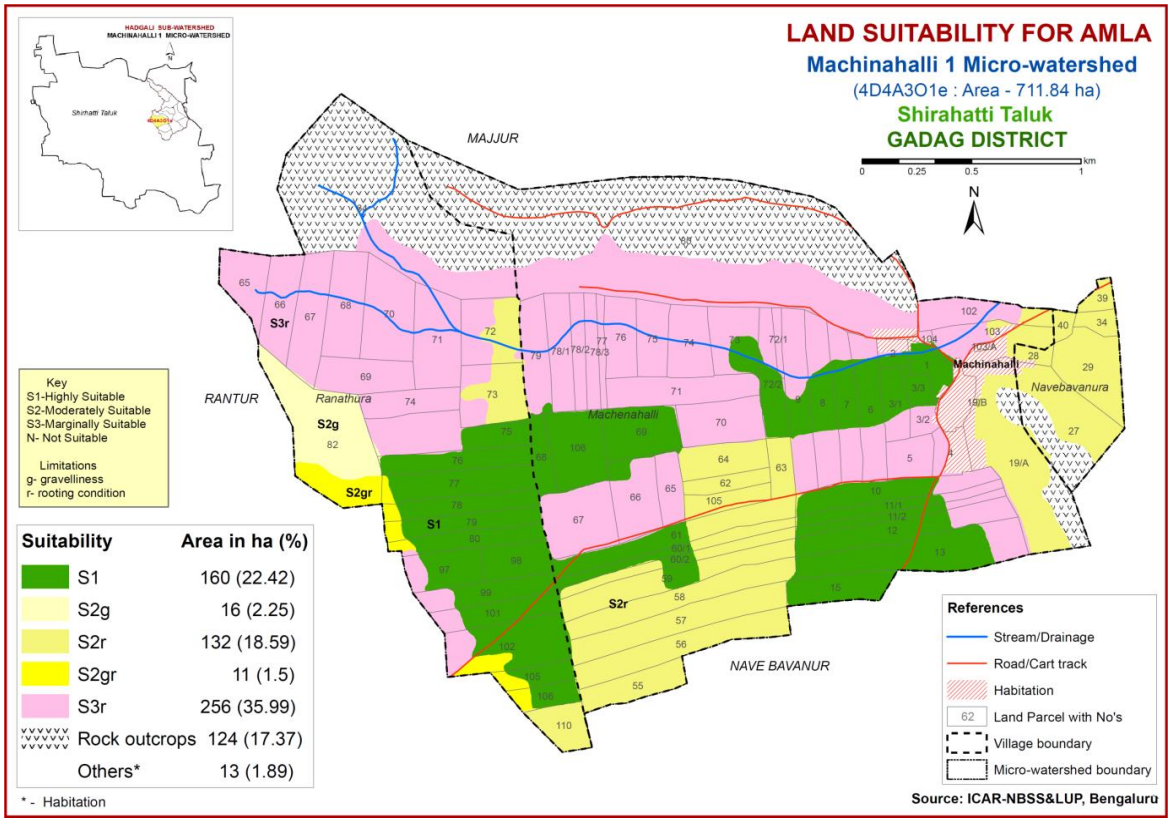


Fig. 7.20 Land Suitability map of Amla

7.21 Land Suitability for Tamarind (*Tamarindus indica*)

Tamarind is the most important spice crop grown in 14897 ha in all the districts of the state. The crop requirements for growing tamarind were matched with the soil-site characteristics and a land suitability map for growing tamarind was generated. The area extent and their geographical distribution of different suitability subclasses in the microwatershed is given in Fig. 7.21.

Moderately suitable (S2) lands occupy a very small area of about 16 ha (2%) and are distributed in the western part of the microwatershed. They have minor limitations of gravelliness and rooting depth. Major area of about 320 ha (45%) is marginally suitable (Class S3) and are distributed in the southwestern, central, southern and eastern part of the microwatershed. They have moderate limitations of rooting depth, texture and gravelliness. An area of about 240 ha (34%) is not suitable (Class N) for growing tamarind and are distributed in the northwestern, central, norheastern and southeastern part of the microwatershed.

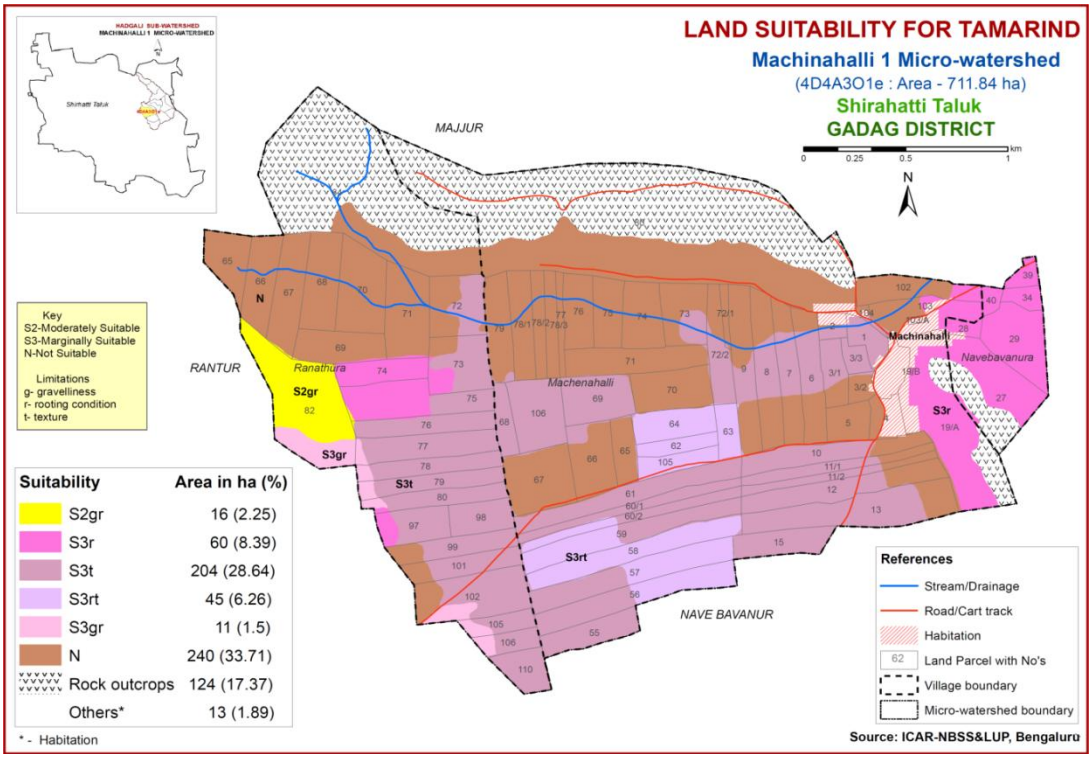


Fig. 7.21 Land Suitability map of Tamarind

7.22 Land Suitability for Marigold (*Tagetes erecta*)

Marigold is the most important flower crop grown in an area of 9108 ha in almost all the districts of the state. The crop requirements for growing marigold were matched with the soil-site characteristics and a land suitability map for growing marigold was generated. The area extent and their geographical distribution of different suitability subclasses in the microwatershed is given in Figure 7.22.

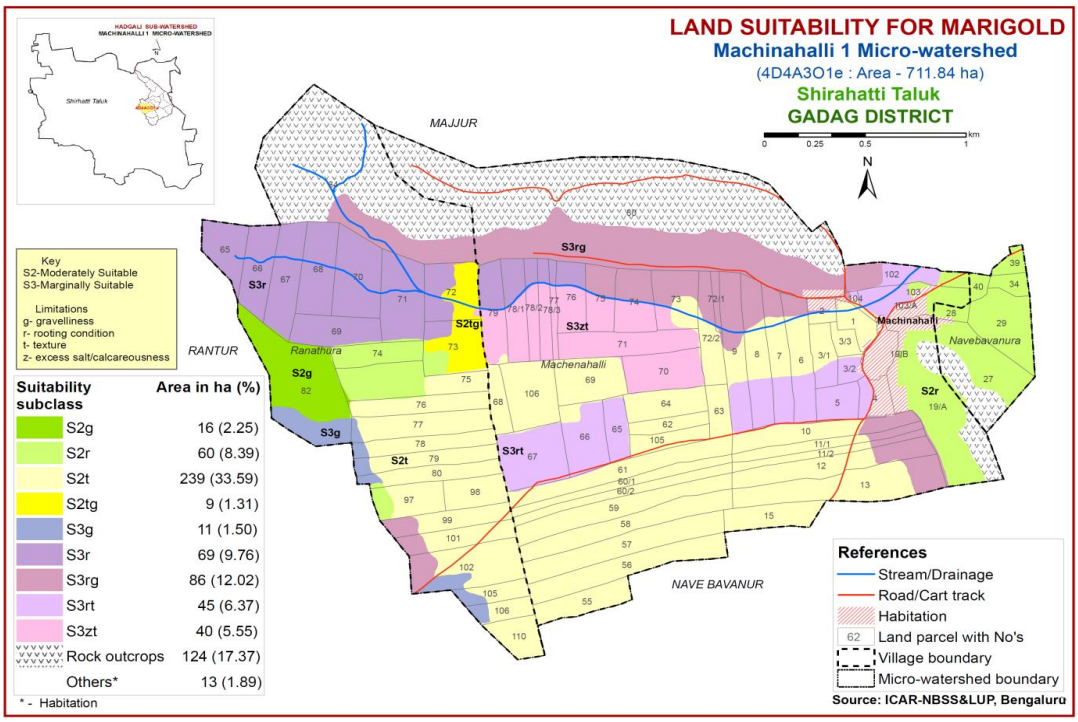


Fig. 7.22 Land Suitability map of Marigold

There are no highly suitable (Class S1) lands for growing marigold. Major area of about 324 ha (45%) has soils that are moderately suitable (Class S2) with minor limitations of gravelliness, rooting depth and texture. They are distributed in the western, central, eastern and southern part of the microwatershed. The marginally suitable (Class S3) lands cover an area of about 251 ha (35%) and occur in the northwestern, central, northeastern and southeastern part of the microwatershed. They have moderate limitations of gravelliness, rooting depth, texture and calcareousness.

7.23 Land Suitability for Chrysanthemum (*Chrysanthemum indicum*)

Chrysanthemum is the most important flower crop grown in an area of 803 ha in almost all the districts of the State. The crop requirements for growing chrysanthemum were matched with the soil-site characteristics and a land suitability map for growing chrysanthemum was generated. The area extent and their geographic distribution of different suitability subclasses in the microwatershed is given in Figure 7.23.

There are no highly suitable (Class S1) lands for growing chrysanthemum. Major area of about 324 ha (45%) has soils that are moderately suitable (Class S2) with minor limitations of gravelliness, rooting depth and texture. They are distributed in the western, central, eastern and southern part of the microwatershed. The marginally suitable (Class S3) lands cover an area of about 251 ha (35%) and occur in the northwestern, central, northeastern and southeastern part of the microwatershed. They have moderate limitations of gravelliness, rooting depth, texture and calcareousness.

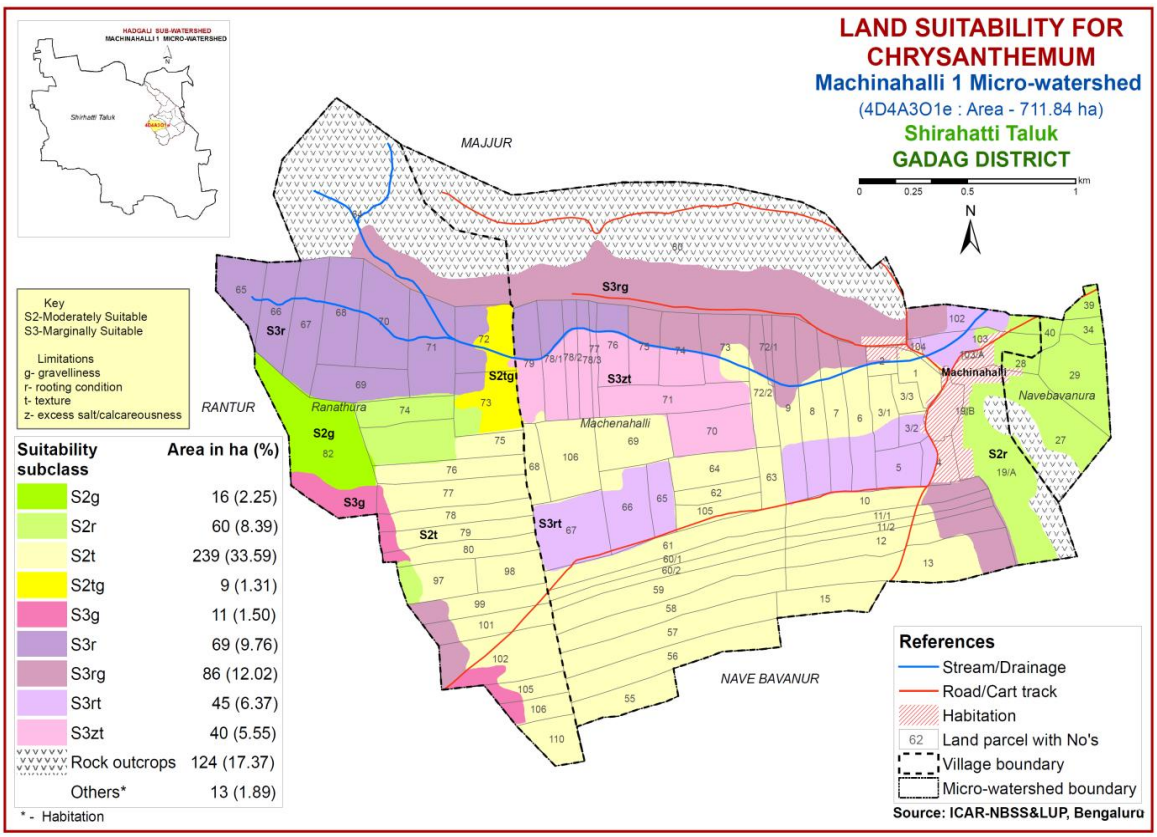


Fig. 7.23 Land Suitability map of Chrysanthemum

7.22 Land Use Classes (LUCs)

The 25 soil map units identified in Machinahalli-1 Microwatershed have been grouped into seven Land Use Classes (LUC's) for the purpose of preparing a Proposed Crop Plan. Land Use Classes are grouped based on the similarities in respect of the type of soil, the depth of the soil, the surface soil texture, gravel content, AWC, slope, erosion etc. and a Land Use classes map (Fig.7.24) has been generated. These land use classes are expected to behave similarly for a given level of management.

The map units that have been grouped into seven land use classes along with brief description of soil and site characteristics are given below.

LUCs	Soil map units	Soil and site characteristics
1	BPRhC3g2	Deep, dark reddish brown to dark red gravelly sandy clay to clay soils with slopes of 1-5% , very gravelly (35-60%) and severe erosion
2	MPTmA2g1 MPTmB1g1 MPTmB2	Deep, moderately well drained, have very dark brown to very dark greyish brown cracking clay soils with slopes of 0-3%, gravelly (15-35%) and slight to moderate erosion
3	JLGmB2 JLGmB1g1 JLGmB2g1 JLGmB2g2	Moderately deep, reddish brown gravelly sandy loam soils with slopes of 1-3%, gravelly to very gravelly (15-60%) and slight to moderate erosion
4	ATTmB2 ATTmB2g1	Moderately shallow, dark brown to very dark brown clayey soils with slopes of 1-3%, gravelly (15-35%) and moderate erosion
5	KTPhB1g1 KTPmC3g1 LKRhC2g2 MKHmB2g1 TDHfB2g1	Moderately shallow, dark brown and dark reddish brown sandy clay loam to clay loam soils with slopes of 1-5%, gravelly to very gravelly (15-60%) and slight to severe erosion
6	KGPfB2g2 KGPfB3g1 KGPfC3g2 KGPfC3g2R2St2 KGPhB1g1 KGPiB2g2	Shallow, brown to dark reddish brown sandy clay loam to sandy clay soils with slopes of 1-5%, slight to severe erosion, gravelly to very gravelly (15-60%), fairly rocky (2-10%) and very stony (0.1-3%)
7	NPTfB2g1 YSJmB2 YSJmB2g1	Shallow, dark gray calcareous clay soils with slopes of 1-3%, gravelly (15-35%) and moderate erosion

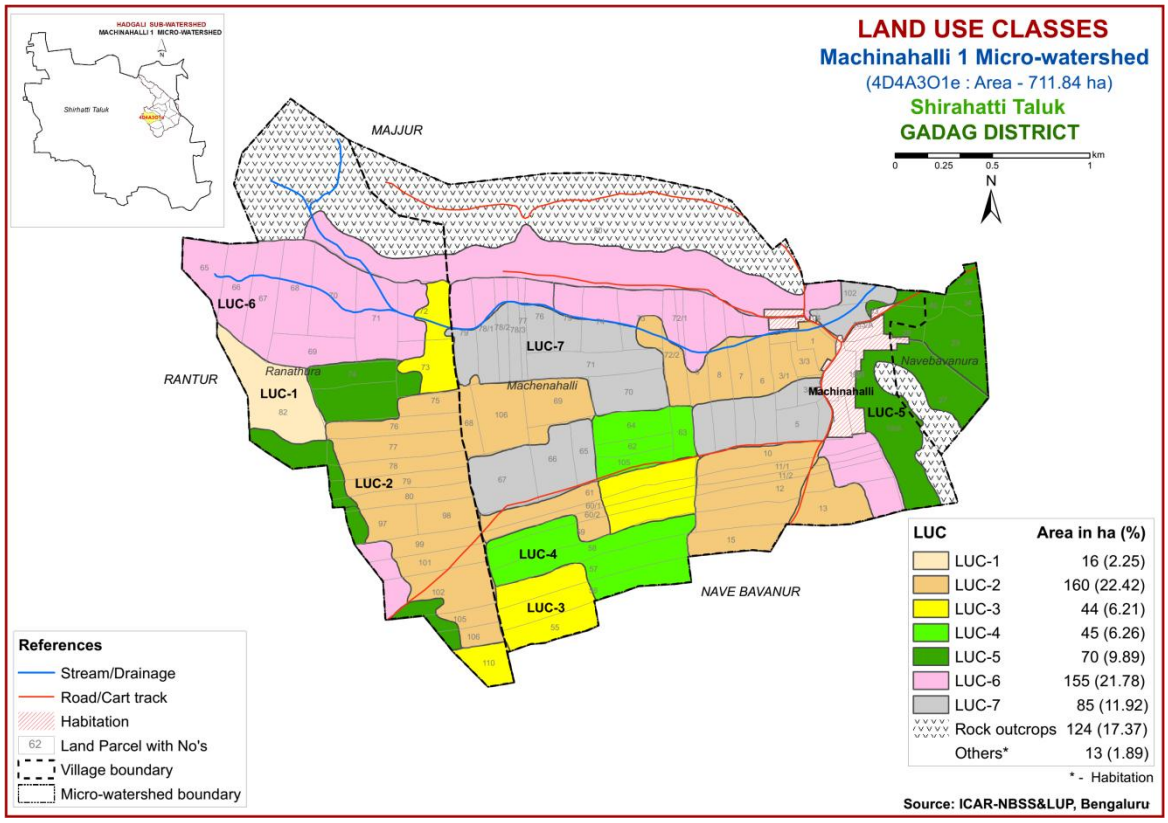


Fig. 7.24 Land Use Classes Map of Machinahalli-1 Microwatershed

7.23 Proposed Crop Plan for Machinahalli-1 Microwatershed

After assessing the land suitability for the 23 crops, the proposed crop plan has been prepared for the seven identified LUCs by considering highly (Class S1) suitable and moderately (Class S2) suitable lands for each of the 23 crops. The resultant Proposed Crop Plan is presented below in Table 7.16.

Table 7.16 Proposed Crop Plan for Machinahalli-1 Microwatershed

LUC No	Mapping Units	Survey Number	Field Crops/ Forestry	Suitable Horticulture Crops under Irrigation	Horticulture Crops with suitable Interventions	Suitable Interventions
LUC 1	3 (100-150 cm) Deep	Ranathura: 82	Ragi, Maize, Groundnut, Sorghum, Sunflower, Bajra, Sesamum, Castor	**Perennial Component:** Mango, Tamarind, Aonla, Pomelo **Intercrops:** Groundnut, Hebbal Avare, Clusterbean, Coriander **Vegetables:** Tomato, Green Chillies, French Bean, Bhendi, Vegetable Cowpea, Cucurbits **Flower Crops:** Marigold, Gaillardia	Mango,Sapota,Guava,Lime, Banana, Papaya, Jamun **Mixed Orchards:** Mango+Guava+Drumsticks + Curry leaf+Sapota+Guava + Drumsticks+Curryleaf **Vegetables**: Tomoto, Capsicum, Green Chillies,French,Bean, Bhendi,Crucifers,Cucurbits **Flower Crops:** Tuberose,Aster, Chrysanthemum,Rose, Jasmine, Spider Lilly	Drip irrigation, Mulching, other suitable conservation practices
LUC 2	18, 19, 20 (100-150 cm) Deep	Machenahalli: 1,2,3/1,3/3,6,7,8,10, 11/1,11/2,12,13,15, 60/1,61,68,69,72/2, 104,106 Ranathura: 76,77,78,79,80,97, 98,99,101,102,105, 106	Sorghum, Redgram, Cotton, Sunflower, Safflower, Linseed, Coriander, Bajra, Bengal gram **Multiple Crop rotation:** Redgram+Fodder jowar Pulses+Sorghum	**Vegetables:** Chillies, Tomato, Bhendi, Onion, Cabbage, Drumstick **Perenial Components:** Tamarind, Custard Apple, Amla, Lime, Moosambi, Pomegranate	**Flower Crops:** Marigold, Gaillardia, Tuberose, Chrysanthemum **Perenial components:** Tamarind, Custard Apple, Amla, Lime, Moosambi, Pomegranate **Vegetables:** Chillies, Bhendi, Crucifers	Drip irrigation, Mulching, other suitable conservation practices
LUC 3	4, 5, 6, 7 (75-100 cm) Moderately deep	Machenahalli: 55,60/2 Ranathura: 73,110	Sorghum, Bajra, Sunflower, Cotton, Safflower **Multiple/Crop rotation:**	**Vegetables:** Chillies, Tomato, Bhendi, Onion, Cabbage, Drumstick **Perenial Components:**	**Flower Crops:** Marigold, Gaillardia, Tuberose, Chrysanthemum **Perenial Components:** Tamarind, Custard Apple,	Drip irrigation, Mulching, other suitable conservation practices

			Redgram+Maize, Redgram+Fodder jowar, Pulses+Sorghum	Tamarind, Custard Apple, Amla, Lime, Moosambi, Pomegranate	Amla, Lime, Moosambi, Pomegranate **Vegetables:** Chillies, Bhendi, Crucifers	
LUC 4	1, 2 (50-75 cm) Moderately shallow	Machenahalli: 56,57,58,59, 62,63,64,105	Sorghum, Cotton, Bajra, Bengal gram, Safflower, Redgram	**Vegetables:** Chillies, Tomato,Bhendi,Cabbage , Drumstick, Onion, Ridge Gouard, Ashguard	Ber, Fig, Aonla, Pomelo	-do-
LUC 5	14, 15, 16, 17, 22 (50-75 cm) Moderately shallow	Machenahalli: 19/A,19/B Navebavanura: 27,28,29,34,39,40 Ranathura: 74,75	Ragi, Bajra,Horsegram, Groundnut	Ber, Custurd Apple **Vegetables:** Cluster Bean, Ridge Gouard, Ash Gouard	Fig, Aonla, Pomelo	Drip irrigation, Mulching, other suitable conservation practices
LUC 6	8, 9, 10, 11, 12,13 (25-50 cm) Shallow	Machenahalli: 9,72/1,73 Ranathura: 65,66,67,68,69,70, 71,72	Groundnut,Horsegram, Greengram **Silviculture:**Simaruba, Acacia auriculiformis, Glyricidia, Subabul, Agave, Cassia sp.	**Vegetables:** Chillies, Tomato	-	-do-
LUC 7	21, 23, 24 Shallow	Machenahalli: 3/2,5,65,66,67, 70,71,74,75,76, 77,78/1,78/2,78/3,7 9,102,103	Bengalgram, Cowpea, Greengram	-	-	-do-

Chapter 8

SOIL HEALTH MANAGEMENT

8.1 Soil Health

Soil is fundamental to crop production. Without soil, no food could be produced nor would livestock be fed on a large scale. Because it is finite and fragile, soil is a precious resource that requires special care from its users.

Soil health or the capacity of the soil to function is critical to human survival. Soil health has been defined as: "the capacity of the soil to function as a living system without adverse effect on the ecosystem". Healthy soils maintain a diverse community of soil organisms that help to form beneficial symbiotic associations with plant roots, recycle essential plant nutrients, improve soil structure with positive repercussions for soil, water and nutrient holding capacity and ultimately improve crop production and also contribute to mitigating climate change by maintaining or increasing its carbon content.

Functional interactions of soil biota with organic and inorganic components, air and water determine a soil's potential to store and release nutrients, and water to plants and to promote and sustain plant growth. Thus, maintaining soil health is vital to crop production and conserve soil resource base for sustaining agriculture.

The most important characterististics of a healthy soil are

- Good soil tilth
- Sufficient soil depth
- Good water storage and good drainage
- Adequate supply, but not excess of nutrients
- Large population of beneficial organisms
- Small proportion of plant pathogens and insect pests
- Low weed pressure
- Free of chemicals and toxins that may harm the crop
- Resistance to degradation
- Resilience when unfavourable conditions occur

Characteristics of Machinahalli-1 Microwatershed

- The soil phases with sizeable area identified in the microwatershed belonged to the soil series of MPT (160 ha), KGP (155 ha), ATT (45 ha), YSJ (45 ha), JLG (44 ha), KTP (43 ha), NPT (39 HA), TDH (16 ha), LKR (7 ha), MKH (3 ha) and BPR (2 ha).
- As per land capability Classification, about 74 per cent area in the microwatershed falls under arable land category (Class II, III and IV). The major limitations identified in the arable lands were soil and erosion.
- On the basis of soil reaction, an area of about 129 ha (18%) is moderately alkaline (pH 7.8-8.4). An area of about 65 ha (9%) is under slightly alkaline (pH 7.3-7.8),

strongly alkaline (8.4-9.0) soils occupy maximum area of 275 ha (39%) and 105 ha (15%) is under neutral (pH 6.5-7.3). Thus, majority of the soils (66%) are alkaline in reaction.

Soil Health Management

The following actions are required to improve the current land husbandry practices that provide a sound basis for the successful adoption of sustainable crop production system.

Alkaline soils

(Slightly alkaline to moderately alkaline soils)

1. Regular addition of organic manure, green manuring, green leaf manuring, crop residue incorporation and mulching needs to be taken up to improve the soil organic matter status.
2. Application of biofertilizers (Azospirullum, Azatobacter, Rhizobium).
3. Application of 25% extra N and P (125 % RDN&P).
4. Application of $ZnSO_4$ – 12.5 kg/ha (once in three years).
5. Application of Boron – 5 kg/ha (once in three years).

Neutral soils

1. Regular addition of organic manure, green manuring, green leaf manuring, crop residue incorporation and mulching needs to be taken up to improve the soil organic matter status.
2. Application of biofertilizers, (Azospirullum, Azotobacter, Rhizobium).
3. Application of 100 per cent RDF.
4. Need based micronutrient applications.

Besides the above recommendations, the best transfer of technology options are also to be adopted.

Acid soils

(Slightly acid to strongly acid soils)

1. Application of lime in the form of calcium carbonate or limestone ($CaCO_3$)
2. Regular addition of organic manure, green manuring, green leaf manuring, crop residue incorporation and mulching needs to be taken up to improve the soil organic matter status.
3. Use of rock phosphate (30-50 % of CaO, which helps in improving soil pH).
4. Application of basic fertilizers (Sodium nitrate, basic slag etc, reduces acidity in acid soils)

Besides the above recommendations, the best transfer of technology options are also to be adopted.

Soil Degradation

Soil erosion is one of the major factor affecting the soil health in the microwatershed. Out of total 712 ha area in the microwatershed, an area of 286 ha is suffering from moderate and 171 ha area under severe erosion. These areas need immediate soil and water conservation and, other land development and land husbandry practices for restoring soil health.

Dissemination of information and communication of benefits

Any large scale implementation of soil health management requires that supporting information is made available widely, particularly through channels familiar to farmers and extension workers. Given the very high priority attached to soil health especially by the Central Government on issuing Soil-Health Cards to all the farmers, media outlets like Regional, State and National Newspapers, Radio and Dooradarshan programs in local languages but also modern information and communication technologies such as Cellular phones and the Internet, which can be much more effective in reaching the younger farmers.

Inputs for Net Planning (Saturation Plan) and Interventions needed

Net planning in IWMP is focusing on preparation of

1. Soil and Water Conservation Treatment Plans for each plot or farm.
2. Productivity enhancement measures/ interventions for existing crops/livestock/other farm enterprises.
3. Diversification of farming mainly with perennial horticultural crops and livestock.
4. Improving livelihood opportunities and income generating activities.

In this connection, how various outputs of Sujala-III are of use in addressing these objectives of Net Planning (Saturation Plan) are briefly presented below.

- **Soil Depth:** The depth of a soil decides the amount of moisture and nutrients it can hold, what crops can be taken up or not, depending on the rooting depth and the length of growing period available for raising any crop. Deeper the soil, better for a wide variety of crops. If sufficient depth is not available for growing deep rooted crops, either choose medium or short duration crops or deeper planting pits need to be opened and additional good quality soil brought from outside has to be filled into the planting pits.
- **Surface soil texture:** Lighter soil texture in the top soil means, better rain water infiltration, less run-off and soil moisture conservation, less capillary rise and less evaporation losses. Lighter surface textured soils are amenable to good soil tilth and are highly suitable for crops like groundnut, root vegetables (carrot, raddish, potato etc) but not ideal for crops that need stagnant water like lowland paddy. Heavy textured soils are poor in water infiltration and percolation. They are prone for sheet

erosion; such soils can be improved by sand mulching. The technology that is developed by the AICRP-Dryland Agriculture, Vijayapura, Karnataka can be adopted.

- **Gravelliness:** More gravel content is favorable for run-off harvesting but poor in soil moisture storage and nutrient availability. It is a significant parameter that decides the kind of crop to be raised.
- **Land Capability Classification:** The land capability map shows the areas suitable and not suitable for agriculture and the major constraints in each of the plot/survey number. Hence, one can decide what kind of enterprise is possible in each of these units. In general, erosion and soil are the major constraints in Machinahalli-1 Microwatershed
- **Organic Carbon:** The OC content (an index of available Nitrogen) is medium (0.5-0.75%) in about 241 ha (34%), low (<0.5%) in 60 ha (8%) and high (>0.5%) in about 274 ha (38%). The areas that are low and medium in OC needs to be further improved by applying farmyard manure and rotating crops with cereals and legumes or mixed cropping.
- **Promoting green manuring:** Growing of green manuring crops costs Rs. 1250/ha (green manuring seeds) and about Rs. 2000/ha towards cultivation that totals to Rs. 3250/- per ha. On the other hand, application of organic manure @ 10 tons/ha costs Rs. 5000/ha. The practice needs to be continued for 2-3 years or more. Nitrogen fertilizer needs to be supplemented by 25% in addition to the recommended level in 301 ha area where OC is less than 0.75% in OC. For example, for rainfed maize, recommended level is 50 kg N per ha and an additional 12 kg /ha needs to be applied for all the crops grown in these plots.
- **Available Phosphorus**: Available phosphorus is low in the microwatershed area of about 364 ha (51%) and 210 ha (30%) medium. Hence for all the crops, 25% additional P-needs to be applied.
- **Available Potassium:** Available potassium is medium in 320 ha (45%) and 255 ha (36%) it is high >337 kg/ha) in available potassium. For all the crops, an additional 25 % potassium may be applied in low and medium potassium content areas.
- **Available Sulphur:** Available sulphur is a very critical nutrient for oilseed crops. Available sulphur is medium (10-20 ppm) in an area of 319 ha (45%) and low in an area of about 256 ha (36%) in the microwatershed. These areas need to be applied with magnesium sulphate or gypsum or Factamphos (p) fertitilizer (13% sulphur) for 2-3 years for the deficiency to be corrected.
- **Available Boron:** Available boron is medium in an area of 268 ha (38%), low in 299 ha (42%) and 8 ha (1%) high in the microwatershed. These low and medium areas need to be applied with sodium borate @ 10 kg/ha as soil application or 0.2% borax as foliar application to correct the boron deficiency.
- **Available iron:** It is deficient in a maximum area of 533 ha (75%) in the microwatershed. To manage iron deficiency, iron sulphate @ 25kg /ha needs to be

applied for 2-3 years. It is sufficient in the rest of 41 ha (6 %) area in the microwatershed.

- **Available Zinc:** It is deficient (<0.6 ppm) in 459 ha (64%) area and sufficient (>0.6 ppm) in 115 ha (16%) in the microwatershed. Application of zinc sulphate @ 25kg/ha is to be followed in deficient areas.
- **Soil alkalinity:** The microwatershed has 469 ha (66%) area with soils that are moderately to strongly alkaline. These areas need application of gypsum and wherever calcium is in excess, iron pyrites and element sulphur can be recommended. Management practices like treating repeatedly with good quality water to drain out the excess salts and provision of subsurface drainage and growing of salt tolerant crops like Casuarina, Acasia, Neem, Ber etc, are recommended.

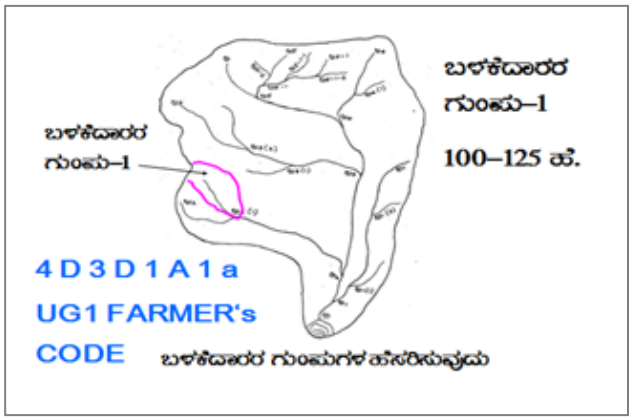
Land Suitability for various crops: Areas that are highly, moderately and marginally suitable for growing various crops are indicated. Along with the suitability, various constraints that are limiting the productivity are also indicated. For example, in case of cotton, gravel content, rooting depth and salinity/alkalinity are the major constraints in various plots. With suitable management interventions, the productivity can be enhanced. In order to increase water holding capacity of light textured soils, growing of green manure crops and application of organic manure is recommended.

Chapter 9

SOIL AND WATER CONSERVATION TREATMENT PLAN

For preparing soil and water conservation treatment plan for Machinahalli-1 Microwatershed, the land resource inventory database generated under Sujala-III project has been transformed as information through series of interpretative (thematic) maps using soil phase map as a base. The various thematic maps (1:7920 scale) generated were

- Soil depth
- Surface soil texture
- Available water capacity
- Soil slope
- Soil gravelliness
- Land capability
- Present land use and land cover
- Crop suitability
- Rainfall
- Hydrology
- Water Resources
- Socio-economic data
- Contour plan with existing features- network of waterways, pothissa boundaries, cut up/ minor terraces etc.
- Cadastral map (1:7920 scale)
- Satellite imagery (1:7920 scale)



Apart from these, Hand Level/ Hydro Marker/ Dumpy Level/ Total Station and Kathedars' List to be collected.

Steps for Survey and Preparation of Treatment Plan

The boundaries of Land User Groups' and Survey No. boundaries are traced in the field.

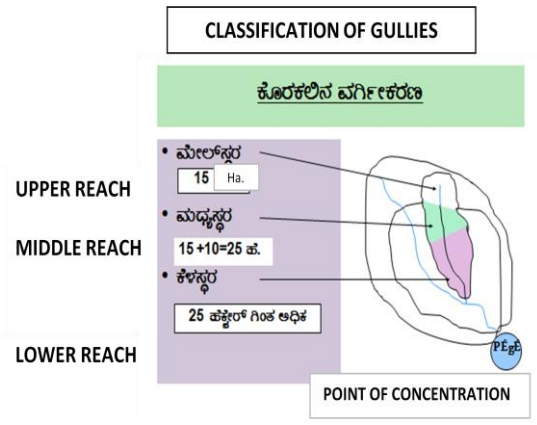
- Naming of user groups and farmers
- Identification of arable and non arable lands
- Identification of drainage lines and gullies
- Identification of non treatable areas
- Identification of priority areas in the arable lands
- Treatment plan for arable lands
- Location of water harvesting and recharge structures

9.1 Treatment Plan

The treatment plan recommended for arable lands is briefly described below.

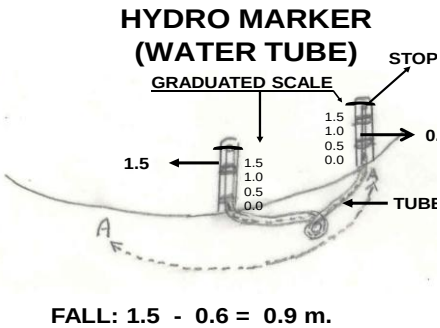
9.1.1 Arable Land Treatment

A. BUNDING

Steps for Survey and Preparation of Treatment Plan		USER GROUP-1
• Cadastral map (1:7920 scale) is enlarged to a scale of 1:2500 scale • Existing network of waterways, pothissa boundaries, grass belts, natural drainage lines/ watercourse, cut ups/ terraces are marked on the cadastral map to the scale • Drainage lines are demarcated into		
Small gullies	(up to 5 ha catchment)	
Medium gullies	(5-15 ha catchment)	
Ravines	(15-25 ha catchment) and	
Halla/Nala	(more than 25ha catchment)	

Measurement of Land Slope

Land slope is estimated or determined by the study and interpretation of contours or by measurement in the field using simple instruments like Hand Level or Hydromarker.



FALL: 1.5 - 0.6 = 0.9 m.

Vertical and Horizontal intervals between bunds as recommended by the Watershed Development Department.

Slope percentage	Vertical interval (m)	Corresponding Horizontal Distance (m)
2 - 3%	0.6	24
3 - 4%	0.9	21
4 - 5%	0.9	21
5 - 6%	1.2	21
6 - 7%	1.2	21

Note: i) The above intervals are maximum.

(ii) Considering the slope class and erosion status (A1… A= 0-1% slope, 1= slight erosion) the intervals have to be decided.

Bund length recording: Considering the contour plan and the existing grass belts/partitions, the bunds are aligned and lengths are measured.

Section of the Bund

Bund section is decided considering the soil texture class and gravelliness class (bg_0 - loamy sand, <15% gravel). The recommended Sections for different soils are given below.

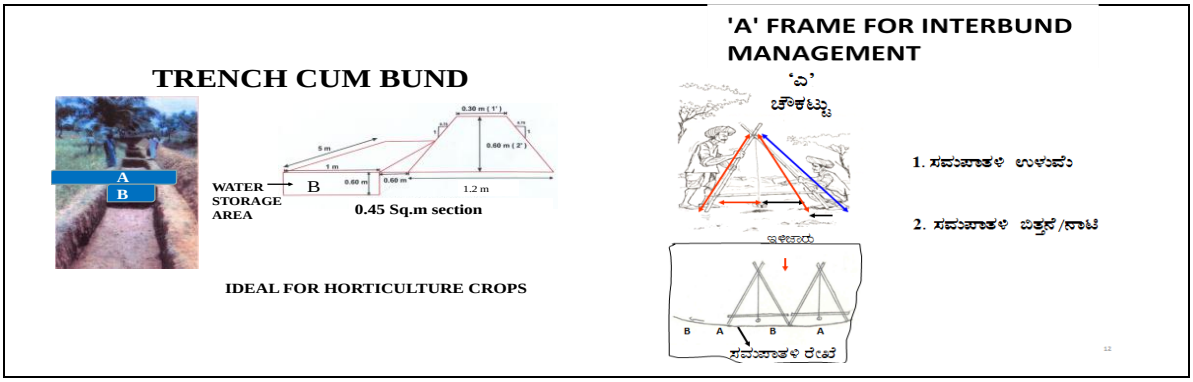
Recommended Bund Section

Top width (m)	Base width (m)	Height (m)	Side slope (Z:1;H:V)	Cross section (sq m)	Soil Texture	Remarks
0.3	0.9	0.3	01:01	0.18	Sandy loam	Vegetative bund
0.3	1.2	0.3	1.5:1	0.225	Sandy clay	
0.3	1.2	0.5	0.9:1	0.375	Red gravelly soils	
0.3	1.2	0.6	0.75:1	0.45		
0.3	1.5	0.6	01:01	0.54	Red sandy loam	
0.3	2.1	0.6	1.5:1	0.72	Very shallow black soils	
0.45	2	0.75	01:01	0.92		
0.45	2.4	0.75	1.3:1	1.07	Shallow black soils	
0.6	3.1	0.7	1.78:1	1.29	Medium black soils	
0.5	3	0.85	1.47:1	1.49		

Formation of Trench cum Bund

Dimensions of the Borrow Pits/ Trenches to be excavated (machinery are decided considering the Bund Section).

Details of Borrow Pit dimensions are given below



Size of Borrow Pits/ Trench recommended for Trench cum Bund (by machinery)

Bund section	Bund length	Earth quantity	Pit				Berm (pit to pit)	Soil depth class
m^2	m	m^3	L(m)	W(m)	D(m)	QUANTITY (m^3)	m	
0.375	6	2.25	5.85	0.85	0.45	2.24	0.15	Shallow
0.45	6	2.7	5.4	1.2	0.43	2.79	0.6	Shallow
0.45	6	2.7	5	0.85	0.65	2.76	1	Moderately Shallow
0.54	5.6	3.02	5.5	0.85	0.7	3.27	0.1	Moderately shallow
0.54	5.5	2.97	5	1.2	0.5	3	0.5	Shallow
0.72	6.2	4.46	6	1.2	0.7	5.04	0.2	Moderately shallow
0.72	5.2	3.74	5.1	0.85	0.9	3.9	0.1	Moderately deep

B. Waterways

a) Existing waterways are marked on the cadastral map (1:7920 scale) and their dimensions are recorded.

b) Considering the contour plan of the MWS, additional waterways/ modernization of the existing ones can be thought of.

c) The design details are given in the Manual.

C. Farm Ponds

Waterways and the catchment area will give an indication on the size of the Farm Pond. Location of the pond can be decided based on the contour plan/ field condition and farmers' need/desire.

D. Diversion channel

Existing EPT/ CPT are marked on the cadastral map. Looking to the need, these can be modernized or fresh diversion channel can be proposed and runoff from this can be stored in Gokatte/ Recharge ponds.

9.1.2 Non-Arable Land Treatment

Depending on the gravelliness and crops preferred by the farmers, the concerned authorities can decide appropriate treatment plan. The recommended treatments may be Contour Trench, Staggered Trench, Crescent Bund, Boulder Bund or Pebble Bund are formed in the field.

9.1.3 Treatment of Natural Water Course/ Drainage Lines

a) The cadastral map has to be updated as regards the network of drainge lines (gullies/ nalas/ hallas) and existing structures are marked to the scale and storage capacity of the existing water bodies are documented.
b) The drainage line will be demarcated into Upper Reach, Middle Reach and Lower Reach.
c) Considering the Catchment, Nala bed and bank conditions, suitable structures are decided.
d) Number of storage structures (Check dam/ Nala bund/ Percolation tank) will be decided from considering the commitments and available runoff water budgeting and quality of water in the wells and site suitability.
e) Detailed Levelling Survey using Dumpy Level / Total Station has to be carried out to arrive at the site-specific designs as shown in the Manual.
f) The location of ground water recharge structures are decided by examining the lineaments and fracture zones from geological maps.
g) Rainfall intensity data of the nearest Rain gauge station is considered for Hydrologic Designs.
h) Silt load to the Storage/Recharge structures is reduced by providing vegetative, boulder and earthern checks in the natural water course. Location and design details are given in the Manual.

9.2 Recommended Soil and Water Conservation Measures

The appropriate conservation structures best suited for each of the land parcel/ survey number (Appendix-I) are selected based on the slope per cent, severity of erosion, amount of rainfall, land use and soil type. The different kinds of conservation structures recommended are

1. Graded / Strengthening of Bunds
2. Trench cum Bunds (TCB)
3. Trench cum Bunds / Strengthening
4. Crescent Bunds

A map (Fig. 9.1) showing soil and water conservation plan with different kinds of structures recommended has been generated which shows the spatial distribution and extent of area. Maximum area of about 415 ha (58%) requires trench cum bunding. About 160 ha (22%) area needs graded bunds or strengthening of existing bunds. The conservation plan prepared may be presented to all the stakeholders including farmers and after including their suggestions, the conservation plan for the microwatershed may be finalised in a participatory approach.

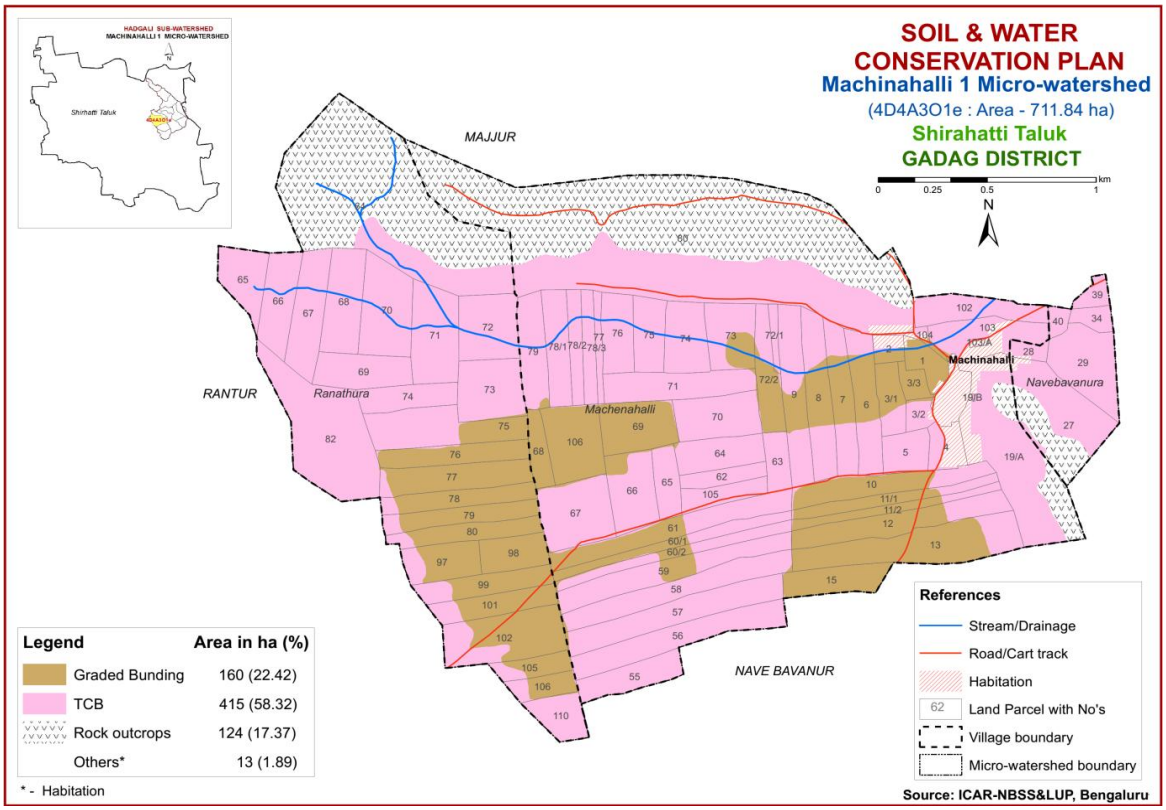


Fig. 9.1 Soil and Water Conservation Plan map of Machinahalli-1 Microwatershed

9.3 Greening of Microwatershed

As part of the greening programme in the watersheds, it is envisaged to plant a variety of horticultural and other tree plants that are edible, economical and produce lot of biomass which helps to restore the ecological balance in the watersheds. The lands that are suitable for greening programme are non-arable lands (land capability Classes V, VI, VII and VIII) and also the lands that are not suitable or marginally suitable for growing annual and perennial crops. The method of planting these trees is given below.

It is recommended to open pits during the 1st week of March along the contour and heap the dug out soil on the lower side of the slope in order to harness the flowing water and facilitate weathering of soil in the pit. Exposure of soil in the pit also prevents spread of pests and diseases due to scorching sun rays. The pits should be filled with mixture of soil and organic manure during the second week of April and keep ready with sufficiently tall seedlings produced either in poly bags or in root trainer nurseries so that planting can be done during the 2nd or 3rd week of April depending on the rainfall.

The tree species suitable for the area considering rainfall, temperature and adaptability is listed below; waterlogged areas are recommended to be planted with species like Neral (*Sizyzium cumini*) and Bamboo. Dry areas are to be planted with species like Honge, Bevu, Seetaphal *etc*.

Sl. No	Dry Deciduous Species		Temp (°C)	Rainfall(mm)
1.	Bevu	*Azadiracta indica*	21–32	400 –1,200
2.	Tapasi	*Holoptelia integrifolia*	20-30	500 - 1000
3.	Seetaphal	*Anona Squamosa*	20-40	400 - 1000
4.	Honge	*Pongamia pinnata*	20 -50	500–2,500
5.	Kamara	*Hardwikia binata*	25 -35	400 - 1000
6.	Bage	*Albezzia lebbek*	20 - 45	500 - 1000
7.	Ficus	*Ficus bengalensis*	20 - 50	500–2,500
8.	Sisso	*Dalbargia Sissoo*	20 - 50	500 -2000
9.	Ailanthus	*Ailanthus excelsa*	20 - 50	500 - 1000
10.	Hale	*Wrightia tinctoria*	25 - 45	500 - 1000
11.	Uded	*Steriospermum chelanoides*	25 - 45	500 -2000
12.	Dhupa	*Boswella Serrata*	20 - 40	500 - 2000
13.	Nelli	*Emblica Officinalis*	20 - 50	500 -1500
14.	Honne	*Pterocarpus marsupium*	20 - 40	500 - 2000
Moist Deciduous Species				
15.	Teak	*Tectona grandis*	20 - 50	500-5000
16.	Nandi	*Legarstroemia lanceolata*	20 - 40	500 - 4000
17.	Honne	*Pterocarpus marsupium*	20 - 40	500 - 3000
18.	Mathi	*Terminalia alata*	20 -50	500 - 2000
19.	Shivane	*Gmelina arboria*	20 -50	500 -2000
20.	Kindal	*T.Paniculata*	20 - 40	500 - 1500
21.	Beete	*Dalbargia latifolia*	20 - 40	500 - 1500
22.	Tare	*T. belerica*	20 - 40	500 - 2000
23.	Bamboo	*Bambusa arundinasia*	20 - 40	500 - 2500
24.	Bamboo	*Dendrocalamus strictus*	20 – 40	500 – 2500
25.	Muthuga	*Butea monosperma*	20 - 40	400 - 1500
26.	Hippe	*Madhuca latifolia*	20 - 40	500 - 2000
27.	Sandal	*Santalum album*	20 - 50	400 - 1000
28.	Nelli	*Emblica officinalis*	20 - 40	500 - 2000
29.	Nerale	*Sizyzium cumini*	20 - 40	500 - 2000
30.	Dhaman	*Grevia tilifolia*	20 - 40	500 - 2000
31.	Kaval	*Careya arborea*	20 - 40	500 - 2000
32.	Harada	*Terminalia chebula*	20 - 40	500 - 2000

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Appendix I

Machinalli-1 Microwatershed

Soil Phase Information

Village	Survey No.	Area (ha)	Soil Phase	LUC	Soil Depth	Surface Soil Texture	Soil Gravelliness	Available Water Capacity	Slope	Soil Erosion	Current Land Use	WELLS	Land Capability	Conservation Plan
Machenahalli	1	3.08	MPTmB2	LUC-2	Deep (100-150 cm)	Clay	Non gravelly (<15%)	Very High (>200 mm/m)	Very gently sloping (1-3%)	Moderate	Cotton (Ct)	Not Available	IIIes	GB
Machenahalli	2	1.8	MPTmB2	LUC-2	Deep (100-150 cm)	Clay	Non gravelly (<15%)	Very High (>200 mm/m)	Very gently sloping (1-3%)	Moderate	Cotton (Ct)	Not Available	IIIes	GB
Machenahalli	3/1	3.88	MPTmB2	LUC-2	Deep (100-150 cm)	Clay	Non gravelly (<15%)	Very High (>200 mm/m)	Very gently sloping (1-3%)	Moderate	Cotton (Ct)	Not Available	IIIes	GB
Machenahalli	3/2	1.75	YSJmB2	LUC-7	Shallow (25-50 cm)	Clay	Non gravelly (<15%)	Low (51-100 mm/m)	Very gently sloping (1-3%)	Moderate	Cotton (Ct)	Not Available	IVes	TCB
Machenahalli	3/3	1.81	MPTmB2	LUC-2	Deep (100-150 cm)	Clay	Non gravelly (<15%)	Very High (>200 mm/m)	Very gently sloping (1-3%)	Moderate	Cotton (Ct)	Not Available	IIIes	GB
Machenahalli	4	3.32	Habitation	Others	Others	Others	Others	Others	Others	Others	Cotton (Ct)	Hand Borewell	Others	Others
Machenahalli	5	3.96	YSJmB2	LUC-7	Shallow (25-50 cm)	Clay	Non gravelly (<15%)	Low (51-100 mm/m)	Very gently sloping (1-3%)	Moderate	Cotton+Maize (Ct+Mz)	Borewell	IVes	TCB
Machenahalli	6	7.67	MPTmB2	LUC-2	Deep (100-150 cm)	Clay	Non gravelly (<15%)	Very High (>200 mm/m)	Very gently sloping (1-3%)	Moderate	Cotton+Maize (Ct+Mz)	Borewell	IIIes	GB
Machenahalli	7	7.11	MPTmB2	LUC-2	Deep (100-150 cm)	Clay	Non gravelly (<15%)	Very High (>200 mm/m)	Very gently sloping (1-3%)	Moderate	Cotton (Ct)	Not Available	IIIes	GB
Machenahalli	8	8.71	MPTmB2	LUC-2	Deep (100-150 cm)	Clay	Non gravelly (<15%)	Very High (>200 mm/m)	Very gently sloping (1-3%)	Moderate	Sugarcane+Cotton+Onion (Sc+Ct+On)	Borewell	IIIes	GB
Machenahalli	9	8.98	KGPfC3g2	LUC-6	Shallow (25-50 cm)	Clay loam	Very gravelly (35-60%)	Very Low (<50 mm/m)	Gently sloping (3-5%)	Severe	Maize+Cotton+Jowar (Mz+Ct+Jw)	3 Borewell	IVes	TCB
Machenahalli	10	8.44	MPTmB2	LUC-2	Deep (100-150 cm)	Clay	Non gravelly (<15%)	Very High (>200 mm/m)	Very gently sloping (1-3%)	Moderate	Cotton+Redgram+Groundnut (Ct+Rg+Gn)	Not Available	IIIes	GB
Machenahalli	11/1	4.74	MPTmB2	LUC-2	Deep (100-150 cm)	Clay	Non gravelly (<15%)	Very High (>200 mm/m)	Very gently sloping (1-3%)	Moderate	Maize+Jowar (Mz+Jw)	Not Available	IIIes	GB
Machenahalli	11/2	3.74	MPTmB2	LUC-2	Deep (100-150 cm)	Clay	Non gravelly (<15%)	Very High (>200 mm/m)	Very gently sloping (1-3%)	Moderate	Jowar+Fallow land (Jw+Fl)	Not Available	IIIes	GB
Machenahalli	12	9.89	MPTmB2	LUC-2	Deep (100-150 cm)	Clay	Non gravelly (<15%)	Very High (>200 mm/m)	Very gently sloping (1-3%)	Moderate	Jowar (Jw)	Borewell	IIIes	GB
Machenahalli	13	15.48	MPTmA2g1	LUC-2	Deep (100-150 cm)	Clay	Gravelly (15-35%)	Very High (>200 mm/m)	Nearly level (0-1%)	Moderate	Jowar+Chilly+Onion+Groundnut (Jw+Ch+On+Gn)	Openwell, 5 Borewell	IIIes	GB
Machenahalli	15	5.84	MPTmB2	LUC-2	Deep (100-150 cm)	Clay	Non gravelly (<15%)	Very High (>200 mm/m)	Very gently sloping (1-3%)	Moderate	Cotton+Jowar (Ct+Jw)	Not Available	IIIes	GB
Machenahalli	19/A	23.67	KTPmC3g1	LUC-5	Moderately shallow (50-75 cm)	Clay	Gravelly (15-35%)	Low (51-100 mm/m)	Gently sloping (3-5%)	Severe	Jowar+Hill area (Jw)	Not Available	IIIes	TCB

Village	Survey No.	Area (ha)	Soil Phase	LUC	Soil Depth	Surface Soil Texture	Soil Gravelliness	Available Water Capacity	Slope	Soil Erosion	Current Land Use	WELLS	Land Capability	Conservation Plan
Machenahalli	19/B	0.06	KTPmC3g1	LUC-5	Moderately shallow (50-75 cm)	Clay	Gravelly (15-35%)	Low (51-100 mm/m)	Gently sloping (3-5%)	Severe	Others	Not Available	IIIes	TCB
Machenahalli	55	5.83	JLGmB2	LUC-3	Moderately deep (75-100 cm)	Clay	Non gravelly (<15%)	Medium (101-150 mm/m)	Very gently sloping (1-3%)	Moderate	Cotton (Ct)	Not Available	IIIes	TCB
Machenahalli	56	11.14	ATTmB2g1	LUC-4	Moderately shallow (50-75 cm)	Clay	Gravelly (15-35%)	Medium (101-150 mm/m)	Very gently sloping (1-3%)	Moderate	Jowar (Jw)	Not Available	IIIes	TCB
Machenahalli	57	11.66	ATTmB2g1	LUC-4	Moderately shallow (50-75 cm)	Clay	Gravelly (15-35%)	Medium (101-150 mm/m)	Very gently sloping (1-3%)	Moderate	Cotton+Jowar (Ct+Jw)	Not Available	IIIes	TCB
Machenahalli	58	10.56	ATTmB2g1	LUC-4	Moderately shallow (50-75 cm)	Clay	Gravelly (15-35%)	Medium (101-150 mm/m)	Very gently sloping (1-3%)	Moderate	Cotton+Jowar (Ct+Jw)	Not Available	IIIes	TCB
Machenahalli	59	10.48	ATTmB2g1	LUC-4	Moderately shallow (50-75 cm)	Clay	Gravelly (15-35%)	Medium (101-150 mm/m)	Very gently sloping (1-3%)	Moderate	Cotton+Jowar (Ct+Jw)	Not Available	IIIes	TCB
Machenahalli	60/1	5.02	MPTmB2	LUC-2	Deep (100-150 cm)	Clay	Non gravelly (<15%)	Very High (>200 mm/m)	Very gently sloping (1-3%)	Moderate	Cotton+Jowar (Ct+Jw)	Not Available	IIIes	GB
Machenahalli	60/2	5.24	JLGmB2g1	LUC-3	Moderately deep (75-100 cm)	Clay	Gravelly (15-35%)	Medium (101-150 mm/m)	Very gently sloping (1-3%)	Moderate	Cotton+Jowar (Ct+Jw)	Not Available	IIIes	TCB
Machenahalli	61	10.33	MPTmB2	LUC-2	Deep (100-150 cm)	Clay	Non gravelly (<15%)	Very High (>200 mm/m)	Very gently sloping (1-3%)	Moderate	Maize+Jowar (Mz+Jw)	Not Available	IIIes	GB
Machenahalli	62	2.9	ATTmB2	LUC-4	Moderately shallow (50-75 cm)	Clay	Non gravelly (<15%)	Medium (101-150 mm/m)	Very gently sloping (1-3%)	Moderate	Cotton+Onion (Ct+On)	2 Borewell	IIIes	TCB
Machenahalli	63	3.02	ATTmB2	LUC-4	Moderately shallow (50-75 cm)	Clay	Non gravelly (<15%)	Medium (101-150 mm/m)	Very gently sloping (1-3%)	Moderate	Cotton+Maize (Ct+Mz)	Not Available	IIIes	TCB
Machenahalli	64	5.89	ATTmB2	LUC-4	Moderately shallow (50-75 cm)	Clay	Non gravelly (<15%)	Medium (101-150 mm/m)	Very gently sloping (1-3%)	Moderate	Cotton+Maize (Ct+Mz)	Not Available	IIIes	TCB
Machenahalli	65	3.73	YSJmB2	LUC-7	Shallow (25-50 cm)	Clay	Non gravelly (<15%)	Low (51-100 mm/m)	Very gently sloping (1-3%)	Moderate	Maize+Cotton+Jowar (Mz+Ct+Jw)	Not Available	IVes	TCB
Machenahalli	66	7.65	YSJmB2	LUC-7	Shallow (25-50 cm)	Clay	Non gravelly (<15%)	Low (51-100 mm/m)	Very gently sloping (1-3%)	Moderate	Maize+Cotton+Jowar (Mz+Ct+Jw)	Not Available	IVes	TCB
Machenahalli	67	9.82	YSJmB2	LUC-7	Shallow (25-50 cm)	Clay	Non gravelly (<15%)	Low (51-100 mm/m)	Very gently sloping (1-3%)	Moderate	Cotton+Maize+Chilly (Ct+Mz+Ch)	Not Available	IVes	TCB
Machenahalli	68	3.03	MPTmB1g1	LUC-2	Deep (100-150 cm)	Clay	Gravelly (15-35%)	Very High (>200 mm/m)	Very gently sloping (1-3%)	Slight	Jowar+Redgram (Jw+Rg)	Not Available	IIIs	GB
Machenahalli	69	7.84	MPTmB1g1	LUC-2	Deep (100-150 cm)	Clay	Gravelly (15-35%)	Very High (>200 mm/m)	Very gently sloping (1-3%)	Slight	Cotton+Groundnut (Ct+Gn)	Not Available	IIIs	GB

Village	Survey No.	Area (ha)	Soil Phase	LUC	Soil Depth	Surface Soil Texture	Soil Gravelliness	Available Water Capacity	Slope	Soil Erosion	Current Land Use	WELLS	Land Capability	Conservation Plan
Machenahalli	70	7.63	NPTfB2g1	LUC-7	Shallow (25-50 cm)	Clay loam	Gravelly (15-35%)	Low (51-100 mm/m)	Very gently sloping (1-3%)	Moderate	Cotton+Redgram (Ct+Rg)	Borewell, Openwell	IVes	TCB
Machenahalli	71	8.78	NPTfB2g1	LUC-7	Shallow (25-50 cm)	Clay loam	Gravelly (15-35%)	Low (51-100 mm/m)	Very gently sloping (1-3%)	Moderate	Cotton+Maize+Redgram (Ct+Mz+Rg)	2 Borewell	IVes	TCB
Machenahalli	72/1	1.08	KGPfC3g2	LUC-6	Shallow (25-50 cm)	Clay loam	Very gravelly (35-60%)	Very Low (<50 mm/m)	Gently sloping (3-5%)	Severe	Cotton (Ct)	Not Available	IVes	TCB
Machenahalli	72/2	5.51	MPTmB2	LUC-2	Deep (100-150 cm)	Clay	Non gravelly (<15%)	Very High (>200 mm/m)	Very gently sloping (1-3%)	Moderate	Cotton+Redgram (Ct+Rg)	Not Available	IIIes	GB
Machenahalli	73	6.8	KGPfC3g2	LUC-6	Shallow (25-50 cm)	Clay loam	Very gravelly (35-60%)	Very Low (<50 mm/m)	Gently sloping (3-5%)	Severe	Maize+Cotton (Mz+Ct)	Borewell	IVes	TCB
Machenahalli	74	6.39	NPTfB2g1	LUC-7	Shallow (25-50 cm)	Clay loam	Gravelly (15-35%)	Low (51-100 mm/m)	Very gently sloping (1-3%)	Moderate	Cotton+Jowar (Ct+Jw)	Not Available	IVes	TCB
Machenahalli	75	4.99	NPTfB2g1	LUC-7	Shallow (25-50 cm)	Clay loam	Gravelly (15-35%)	Low (51-100 mm/m)	Very gently sloping (1-3%)	Moderate	Maize+Cotton (Mz+Ct)	Borewell	IVes	TCB
Machenahalli	76	5.36	NPTfB2g1	LUC-7	Shallow (25-50 cm)	Clay loam	Gravelly (15-35%)	Low (51-100 mm/m)	Very gently sloping (1-3%)	Moderate	Cotton+Maize (Ct+Mz)	Borewell, Openwell	IVes	TCB
Machenahalli	77	1.65	NPTfB2g1	LUC-7	Shallow (25-50 cm)	Clay loam	Gravelly (15-35%)	Low (51-100 mm/m)	Very gently sloping (1-3%)	Moderate	NA	Not Available	IVes	TCB
Machenahalli	78/1	5.9	NPTfB2g1	LUC-7	Shallow (25-50 cm)	Clay loam	Gravelly (15-35%)	Low (51-100 mm/m)	Very gently sloping (1-3%)	Moderate	Maize+Cotton+Jowar (Mz+Ct+Jw)	Borewell	IVes	TCB
Machenahalli	78/2	3.26	NPTfB2g1	LUC-7	Shallow (25-50 cm)	Clay loam	Gravelly (15-35%)	Low (51-100 mm/m)	Very gently sloping (1-3%)	Moderate	Maize+Fallow land (Mz+Fl)	Not Available	IVes	TCB
Machenahalli	78/3	3.16	NPTfB2g1	LUC-7	Shallow (25-50 cm)	Clay loam	Gravelly (15-35%)	Low (51-100 mm/m)	Very gently sloping (1-3%)	Moderate	NA	Openwell	IVes	TCB
Machenahalli	79	6.47	NPTfB2g1	LUC-7	Shallow (25-50 cm)	Clay loam	Gravelly (15-35%)	Low (51-100 mm/m)	Very gently sloping (1-3%)	Moderate	Cotton+Maize (Ct+Mz)	Not Available	IVes	TCB
Machenahalli	80	105.77	Rockout crop	Rock outcrops	Rockout crop	Rockout crop	Rockout crop	Rock outcrops	Rockout crop	Rockout crop	Scrub land+Hill area (Sl)	Not Available	VIII	Rock outcrops
Machenahalli	102	6.5	YSJmB2g1	LUC-7	Shallow (25-50 cm)	Clay	Gravelly (15-35%)	Low (51-100 mm/m)	Very gently sloping (1-3%)	Moderate	Cotton+Jowar (Ct+Jw)	Borewell	IVes	TCB
Machenahalli	103	7.5	YSJmB2g1	LUC-7	Shallow (25-50 cm)	Clay	Gravelly (15-35%)	Low (51-100 mm/m)	Very gently sloping (1-3%)	Moderate	Cotton+Jowar (Ct+Jw)	Not Available	IVes	TCB
Machenahalli	103/A	0.31	Habitation	Others	Others	Others	Others	Others	Others	Others	Cotton+Jowar (Ct+Jw)	Not Available	Others	Others
Machenahalli	104	0.79	MPTmB2	LUC-2	Deep (100-150 cm)	Clay	Non gravelly (<15%)	Very High (>200 mm/m)	Very gently sloping (1-3%)	Moderate	Cotton (Ct)	Not Available	IIIes	GB
Machenahalli	105	3.63	ATTmB2	LUC-4	Moderately shallow (50-75 cm)	Clay	Non gravelly (<15%)	Medium (101-150 mm/m)	Very gently sloping (1-3%)	Moderate	Cotton+Maize+Redgram (Ct+Mz+Rg)	Not Available	IIIes	TCB
Machenahalli	106	8.73	MPTmB1g1	LUC-2	Deep (100-150 cm)	Clay	Gravelly (15-35%)	Very High (>200 mm/m)	Very gently sloping (1-3%)	Slight	Maize+Jowar (Mz+Jw)	Not Available	IIIs	GB

Village	Survey No.	Area (ha)	Soil Phase	LUC	Soil Depth	Surface Soil Texture	Soil Gravelliness	Available Water Capacity	Slope	Soil Erosion	Current Land Use	WELLS	Land Capability	Conservation Plan
Navebavanura	27	15.55	KTPmC3g1	LUC-5	Moderately shallow (50-75 cm)	Clay	Gravelly (15-35%)	Low (51-100 mm/m)	Gently sloping (3-5%)	Severe	Jowar+Hill area (Jw)	Not Available	IIIes	TCB
Navebavanura	28	1.4	KTPhB1g1	LUC-5	Moderately shallow (50-75 cm)	Sandy clay loam	Gravelly (15-35%)	Low (51-100 mm/m)	Very gently sloping (1-3%)	Slight	Jowar (Jw)	Not Available	IIs	TCB
Navebavanura	29	9.47	KTPhB1g1	LUC-5	Moderately shallow (50-75 cm)	Sandy clay loam	Gravelly (15-35%)	Low (51-100 mm/m)	Very gently sloping (1-3%)	Slight	Jowar+Hill area (Jw)	Not Available	IIs	TCB
Navebavanura	34	1.86	KTPhB1g1	LUC-5	Moderately shallow (50-75 cm)	Sandy clay loam	Gravelly (15-35%)	Low (51-100 mm/m)	Very gently sloping (1-3%)	Slight	Sugarcane+ Onion (Sc+On)	Borewell	IIs	TCB
Navebavanura	39	1.68	KTPhB1g1	LUC-5	Moderately shallow (50-75 cm)	Sandy clay loam	Gravelly (15-35%)	Low (51-100 mm/m)	Very gently sloping (1-3%)	Slight	Maize (Mz)	Borewell	IIs	TCB
Navebavanura	40	1.2	KTPhB1g1	LUC-5	Moderately shallow (50-75 cm)	Sandy clay loam	Gravelly (15-35%)	Low (51-100 mm/m)	Very gently sloping (1-3%)	Slight	Maize (Mz)	Not Available	IIs	TCB
Ranathura	64	52.89	Rockout crop	Rock outcrops	Rockout crop	Rockout crop	Rockout crop	Rock outcrops	Rockout crop	Rockout crop	Scrub land+Forest +Hill area (Sl+F)	Not Available	VIII	Rock outcrops
Ranathura	65	5.71	KGPfB3g1	LUC-6	Shallow (25-50 cm)	Clay loam	Gravelly (15-35%)	Very Low (<50 mm/m)	Very gently sloping (1-3%)	Severe	Forest (F)	Not Available	IVes	TCB
Ranathura	66	6.82	KGPfB3g1	LUC-6	Shallow (25-50 cm)	Clay loam	Gravelly (15-35%)	Very Low (<50 mm/m)	Very gently sloping (1-3%)	Severe	Forest (F)	Not Available	IVes	TCB
Ranathura	67	8.26	KGPfB3g1	LUC-6	Shallow (25-50 cm)	Clay loam	Gravelly (15-35%)	Very Low (<50 mm/m)	Very gently sloping (1-3%)	Severe	Forest (F)	Not Available	IVes	TCB
Ranathura	68	8.18	KGPfB3g1	LUC-6	Shallow (25-50 cm)	Clay loam	Gravelly (15-35%)	Very Low (<50 mm/m)	Very gently sloping (1-3%)	Severe	Forest (F)	Not Available	IVes	TCB
Ranathura	69	6.74	KGPfB3g1	LUC-6	Shallow (25-50 cm)	Clay loam	Gravelly (15-35%)	Very Low (<50 mm/m)	Very gently sloping (1-3%)	Severe	Eucalyptous trees+Forest (Eu+F)	Not Available	IVes	TCB
Ranathura	70	9.99	KGPfB3g1	LUC-6	Shallow (25-50 cm)	Clay loam	Gravelly (15-35%)	Very Low (<50 mm/m)	Very gently sloping (1-3%)	Severe	Eucalyptous trees+Forest (Eu+F)	Not Available	IVes	TCB
Ranathura	71	9.61	KGPfB3g1	LUC-6	Shallow (25-50 cm)	Clay loam	Gravelly (15-35%)	Very Low (<50 mm/m)	Very gently sloping (1-3%)	Severe	Eucalyptous trees+Forest (Eu+F)	Not Available	IVes	TCB
Ranathura	72	8.23	KGPfB3g1	LUC-6	Shallow (25-50 cm)	Clay loam	Gravelly (15-35%)	Very Low (<50 mm/m)	Very gently sloping (1-3%)	Severe	Maize+Cotton+Banana (Mz+Ct+Bn)	2 Borewell	IVes	TCB
Ranathura	73	8.31	JLGmB2g2	LUC-3	Moderately deep (75-100 cm)	Clay	Very gravelly (35-60%)	Medium (101-150 mm/m)	Very gently sloping (1-3%)	Moderate	Maize+Jowar+Redgram (Mz+Jw+Rg)	5 Borewell	IIIes	TCB
Ranathura	74	5.05	TDHfB2g1	LUC-5	Moderately shallow (50-75 cm)	Clay loam	Gravelly (15-35%)	Low (51-100 mm/m)	Very gently sloping (1-3%)	Moderate	Maize+Cotton (Mz+Ct)	Not Available	IIs	TCB

Village	Survey No.	Area (ha)	Soil Phase	LUC	Soil Depth	Surface Soil Texture	Soil Gravelliness	Available Water Capacity	Slope	Soil Erosion	Current Land Use	WELLS	Land Capability	Conservation Plan
Ranathura	75	10.84	TDHfB2g1	LUC-5	Moderately shallow (50-75 cm)	Clay loam	Gravelly (15-35%)	Low (51-100 mm/m)	Very gently sloping (1-3%)	Moderate	Jowar+Redgram (Jw+Rg)	Not Available	IIs	TCB
Ranathura	76	6.31	MPTmB1g1	LUC-2	Deep (100-150 cm)	Clay	Gravelly (15-35%)	Very High (>200 mm/m)	Very gently sloping (1-3%)	Slight	Jowar (Jw)	Not Available	IIIs	GB
Ranathura	77	8.45	MPTmB1g1	LUC-2	Deep (100-150 cm)	Clay	Gravelly (15-35%)	Very High (>200 mm/m)	Very gently sloping (1-3%)	Slight	Jowar+Fallow land (Jw+Fl)	Not Available	IIIs	GB
Ranathura	78	5.83	MPTmB1g1	LUC-2	Deep (100-150 cm)	Clay	Gravelly (15-35%)	Very High (>200 mm/m)	Very gently sloping (1-3%)	Slight	Maize+Redgram (Mz+Rg)	Not Available	IIIs	GB
Ranathura	79	5.87	MPTmB1g1	LUC-2	Deep (100-150 cm)	Clay	Gravelly (15-35%)	Very High (>200 mm/m)	Very gently sloping (1-3%)	Slight	Maize+Jowar (Mz+Jw)	Not Available	IIIs	GB
Ranathura	80	5.57	MPTmB1g1	LUC-2	Deep (100-150 cm)	Clay	Gravelly (15-35%)	Very High (>200 mm/m)	Very gently sloping (1-3%)	Slight	Jowar (Jw)	Not Available	IIIs	GB
Ranathura	82	20.63	BPRhC3g2	LUC-1	Deep (100-150 cm)	Sandy clay loam	Very gravelly (35-60%)	Low (51-100 mm/m)	Gently sloping (3-5%)	Severe	Scrub land+Hill area (Sl)	Not Available	IIIes	TCB
Ranathura	97	5.93	MPTmB1g1	LUC-2	Deep (100-150 cm)	Clay	Gravelly (15-35%)	Very High (>200 mm/m)	Very gently sloping (1-3%)	Slight	Jowar (Jw)	Not Available	IIIs	GB
Ranathura	98	4.84	MPTmB1g1	LUC-2	Deep (100-150 cm)	Clay	Gravelly (15-35%)	Very High (>200 mm/m)	Very gently sloping (1-3%)	Slight	Jowar (Jw)	Not Available	IIIs	GB
Ranathura	99	6.05	MPTmB1g1	LUC-2	Deep (100-150 cm)	Clay	Gravelly (15-35%)	Very High (>200 mm/m)	Very gently sloping (1-3%)	Slight	Jowar (Jw)	Not Available	IIIs	GB
Ranathura	101	5.76	MPTmB1g1	LUC-2	Deep (100-150 cm)	Clay	Gravelly (15-35%)	Very High (>200 mm/m)	Very gently sloping (1-3%)	Slight	Jowar (Jw)	Not Available	IIIs	GB
Ranathura	102	12.07	MPTmB1g1	LUC-2	Deep (100-150 cm)	Clay	Gravelly (15-35%)	Very High (>200 mm/m)	Very gently sloping (1-3%)	Slight	Jowar+Sunflower (Jw+Sf)	Not Available	IIIs	GB
Ranathura	105	3.29	MPTmB1g1	LUC-2	Deep (100-150 cm)	Clay	Gravelly (15-35%)	Very High (>200 mm/m)	Very gently sloping (1-3%)	Slight	Jowar (Jw)	Not Available	IIIs	GB
Ranathura	106	3.08	MPTmB1g1	LUC-2	Deep (100-150 cm)	Clay	Gravelly (15-35%)	Very High (>200 mm/m)	Very gently sloping (1-3%)	Slight	Jowar (Jw)	Not Available	IIIs	GB
Ranathura	110	4.46	JLGmB1g1	LUC-3	Moderately deep (75-100 cm)	Clay	Gravelly (15-35%)	Medium (101-150 mm/m)	Very gently sloping (1-3%)	Slight	Jowar (Jw)	Not Available	IIIes	TCB

Appendix II

Machinalli-1 Microwaterhed

Soil Fertility Information

Village	Survey. No.	Soil Reaction	Salinity	Organic Carbon	Available Phosphorus	Available Potassium	Available Sulphur	Available Boron	Available Iron	Available Manganese	Available Copper	Available Zinc
Machenahalli	1	Strongly alkaline (pH 8.4-9.0)	Non Saline (<2 dsm)	High (>0.75 %)	Low (<23 kg/ha)	High (>337 kg/ha)	Low (<10 ppm)	Low (<0.5 ppm)	Deficient (<4.5 ppm)	Sufficient (>1.0 ppm)	Sufficient (>0.2 ppm)	Deficient (<0.6 ppm)
Machenahalli	2	Moderately alkaline (pH 7.8-8.4)	Non Saline (<2 dsm)	High (>0.75 %)	Low (<23 kg/ha)	High (>337 kg/ha)	Low (<10 ppm)	Low (<0.5 ppm)	Deficient (<4.5 ppm)	Sufficient (>1.0 ppm)	Sufficient (>0.2 ppm)	Deficient (<0.6 ppm)
Machenahalli	3/1	Strongly alkaline (pH 8.4-9.0)	Non Saline (<2 dsm)	Medium (0.5-0.75 %)	Low (<23 kg/ha)	High (>337 kg/ha)	Medium (10-20 ppm)	Medium (0.5-1.0 ppm)	Deficient (<4.5 ppm)	Sufficient (>1.0 ppm)	Sufficient (>0.2 ppm)	Deficient (<0.6 ppm)
Machenahalli	3/2	Strongly alkaline (pH 8.4-9.0)	Non Saline (<2 dsm)	Medium (0.5-0.75 %)	Medium (23-57kg/ha)	High (>337 kg/ha)	Medium (10-20 ppm)	Medium (0.5-1.0 ppm)	Deficient (<4.5 ppm)	Sufficient (>1.0 ppm)	Sufficient (>0.2 ppm)	Deficient (<0.6 ppm)
Machenahalli	3/3	Strongly alkaline (pH 8.4-9.0)	Non Saline (<2 dsm)	Medium (0.5-0.75 %)	Low (<23 kg/ha)	High (>337 kg/ha)	Low (<10 ppm)	Low (<0.5 ppm)	Deficient (<4.5 ppm)	Sufficient (>1.0 ppm)	Sufficient (>0.2 ppm)	Deficient (<0.6 ppm)
Machenahalli	4	Others	Others	Others	Others	Others	Others	Others	Others	Others	Others	Others
Machenahalli	5	Strongly alkaline (pH 8.4-9.0)	Non Saline (<2 dsm)	Medium (0.5-0.75 %)	Medium (23-57 kg/ha)	Medium (145-337 kg/ha)	Medium (10-20 ppm)	Medium (0.5-1.0 ppm)	Deficient (<4.5 ppm)	Sufficient (>1.0 ppm)	Sufficient (>0.2 ppm)	Deficient (<0.6 ppm)
Machenahalli	6	Strongly alkaline (pH 8.4-9.0)	Non Saline (<2 dsm)	Medium (0.5-0.75 %)	Low (<23 kg/ha)	High (>337 kg/ha)	Medium (10-20 ppm)	Medium (0.5-1.0 ppm)	Deficient (<4.5 ppm)	Sufficient (>1.0 ppm)	Sufficient (>0.2 ppm)	Deficient (<0.6 ppm)
Machenahalli	7	Strongly alkaline (pH 8.4-9.0)	Non Saline (<2 dsm)	Medium (0.5-0.75 %)	Low (<23 kg/ha)	Medium (145-337 kg/ha)	Medium (10-20 ppm)	Medium (0.5-1.0 ppm)	Deficient (<4.5 ppm)	Sufficient (>1.0 ppm)	Sufficient (>0.2 ppm)	Deficient (<0.6 ppm)
Machenahalli	8	Strongly alkaline (pH 8.4-9.0)	Non Saline (<2 dsm)	High (>0.75 %)	Low (<23 kg/ha)	High (>337 kg/ha)	Medium (10-20 ppm)	Medium (0.5-1.0 ppm)	Deficient (<4.5 ppm)	Sufficient (>1.0 ppm)	Sufficient (>0.2 ppm)	Deficient (<0.6 ppm)
Machenahalli	9	Strongly alkaline (pH 8.4-9.0)	Non Saline (<2 dsm)	High (>0.75 %)	Low (<23 kg/ha)	High (>337 kg/ha)	Medium (10-20 ppm)	Medium (0.5-1.0 ppm)	Deficient (<4.5 ppm)	Sufficient (>1.0 ppm)	Sufficient (>0.2 ppm)	Deficient (<0.6 ppm)
Machenahalli	10	Strongly alkaline (pH 8.4-9.0)	Non Saline (<2 dsm)	Low (<0.5 %)	Medium (23-57 kg/ha)	High (>337 kg/ha)	Medium (10-20 ppm)	Medium (0.5-1.0 ppm)	Deficient (<4.5 ppm)	Sufficient (>1.0 ppm)	Sufficient (>0.2 ppm)	Deficient (<0.6 ppm)
Machenahalli	11/1	Strongly alkaline (pH 8.4-9.0)	Non Saline (<2 dsm)	Medium (0.5-0.75 %)	Medium (23-57 kg/ha)	High (>337 kg/ha)	Medium (10-20 ppm)	Medium (0.5-1.0 ppm)	Deficient (<4.5 ppm)	Sufficient (>1.0 ppm)	Sufficient (>0.2 ppm)	Deficient (<0.6 ppm)
Machenahalli	11/2	Strongly alkaline (pH 8.4-9.0)	Non Saline (<2 dsm)	Medium (0.5-0.75 %)	Medium (23-57 kg/ha)	High (>337 kg/ha)	Medium (10-20 ppm)	Medium (0.5-1.0 ppm)	Deficient (<4.5 ppm)	Sufficient (>1.0 ppm)	Sufficient (>0.2 ppm)	Deficient (<0.6 ppm)
Machenahalli	12	Strongly alkaline (pH 8.4-9.0)	Non Saline (<2 dsm)	Medium (0.5-0.75 %)	Medium (23-57 kg/ha)	High (>337 kg/ha)	Medium (10-20 ppm)	Low (<0.5 ppm)	Deficient (<4.5 ppm)	Sufficient (>1.0 ppm)	Sufficient (>0.2 ppm)	Deficient (<0.6 ppm)
Machenahalli	13	Strongly alkaline (pH 8.4-9.0)	Non Saline (<2 dsm)	Medium (0.5-0.75 %)	Medium (23-57 kg/ha)	High (>337 kg/ha)	Medium (10-20 ppm)	Low (<0.5 ppm)	Deficient (<4.5 ppm)	Sufficient (>1.0 ppm)	Sufficient (>0.2 ppm)	Deficient (<0.6 ppm)
Machenahalli	15	Strongly alkaline (pH 8.4-9.0)	Non Saline (<2 dsm)	Medium (0.5-0.75 %)	Low (<23 kg/ha)	High (>337 kg/ha)	Medium (10-20 ppm)	Low (<0.5 ppm)	Deficient (<4.5 ppm)	Sufficient (>1.0 ppm)	Sufficient (>0.2 ppm)	Deficient (<0.6 ppm)
Machenahalli	19/A	Moderately alkaline (pH 7.8-8.4)	Non Saline (<2 dsm)	Medium (0.5-0.75 %)	Medium (23-57 kg/ha)	High (>337 kg/ha)	Medium (10-20 ppm)	Medium (0.5-1.0 ppm)	Deficient (<4.5 ppm)	Sufficient (>1.0 ppm)	Sufficient (>0.2 ppm)	Sufficient (>0.6 ppm)
Machenahalli	19/B	Moderately alkaline (pH 7.8-8.4)	Non Saline (<2 dsm)	High (>0.75 %)	Medium (23-57 kg/ha)	High (>337 kg/ha)	Medium (10-20 ppm)	Medium (0.5-1.0 ppm)	Deficient (<4.5 ppm)	Sufficient (>1.0 ppm)	Sufficient (>0.2 ppm)	Sufficient (>0.6 ppm)
Machenahalli	55	Strongly alkaline (pH 8.4-9.0)	Non Saline (<2 dsm)	High (>0.75 %)	Medium (23-57 kg/ha)	Medium (145-337 kg/ha)	Low (<10 ppm)	Low (<0.5 ppm)	Deficient (<4.5 ppm)	Sufficient (>1.0 ppm)	Sufficient (>0.2 ppm)	Deficient (<0.6 ppm)
Machenahalli	56	Strongly alkaline (pH 8.4-9.0)	Non Saline (<2 dsm)	High (>0.75 %)	Medium (23-57 kg/ha)	Medium (145-337 kg/ha)	Low (<10 ppm)	Low (<0.5 ppm)	Deficient (<4.5 ppm)	Sufficient (>1.0 ppm)	Sufficient (>0.2 ppm)	Deficient (<0.6 ppm)
Machenahalli	57	Strongly alkaline (pH 8.4-9.0)	Non Saline (<2 dsm)	Medium (0.5-0.75 %)	Medium (23-57 kg/ha)	High (>337 kg/ha)	Low (<10 ppm)	Low (<0.5 ppm)	Deficient (<4.5 ppm)	Sufficient (>1.0 ppm)	Sufficient (>0.2 ppm)	Deficient (<0.6 ppm)

Village	Survey. No.	Soil Reaction	Salinity	Organic Carbon	Available Phosphorus	Available Potassium	Available Sulphur	Available Boron	Available Iron	Available Manganese	Available Copper	Available Zinc
Machenahalli	58	Strongly alkaline (pH 8.4-9.0)	Non Saline (<2 dsm)	Medium (0.5-0.75 %)	Low (<23 kg/ha)	High (>337 kg/ha)	Low (<10 ppm)	Low (<0.5 ppm)	Deficient (<4.5 ppm)	Sufficient (>1.0 ppm)	Sufficient (>0.2 ppm)	Deficient (<0.6 ppm)
Machenahalli	59	Strongly alkaline (pH 8.4-9.0)	Non Saline (<2 dsm)	Medium (0.5-0.75 %)	Low (<23 kg/ha)	High (>337 kg/ha)	Low (<10 ppm)	Low (<0.5 ppm)	Deficient (<4.5 ppm)	Sufficient (>1.0 ppm)	Sufficient (>0.2 ppm)	Deficient (<0.6 ppm)
Machenahalli	60/1	Strongly alkaline (pH 8.4-9.0)	Non Saline (<2 dsm)	Medium (0.5-0.75 %)	Medium (23-57 kg/ha)	High (>337 kg/ha)	Medium (10-20 ppm)	Low (<0.5 ppm)	Deficient (<4.5 ppm)	Sufficient (>1.0 ppm)	Sufficient (>0.2 ppm)	Deficient (<0.6 ppm)
Machenahalli	60/2	Strongly alkaline (pH 8.4-9.0)	Non Saline (<2 dsm)	Medium (0.5-0.75 %)	Medium (23-57 kg/ha)	High (>337 kg/ha)	Low (<10 ppm)	Low (<0.5 ppm)	Deficient (<4.5 ppm)	Sufficient (>1.0 ppm)	Sufficient (>0.2 ppm)	Deficient (<0.6 ppm)
Machenahalli	61	Strongly alkaline (pH 8.4-9.0)	Non Saline (<2 dsm)	Medium (0.5-0.75 %)	Medium (23-57 kg/ha)	High (>337 kg/ha)	Medium (10-20 ppm)	Low (<0.5 ppm)	Deficient (<4.5 ppm)	Sufficient (>1.0 ppm)	Sufficient (>0.2 ppm)	Deficient (<0.6 ppm)
Machenahalli	62	Strongly alkaline (pH 8.4-9.0)	Non Saline (<2 dsm)	Low (<0.5 %)	Medium (23-57 kg/ha)	High (>337 kg/ha)	Medium (10-20 ppm)	Low (<0.5 ppm)	Deficient (<4.5 ppm)	Sufficient (>1.0 ppm)	Sufficient (>0.2 ppm)	Deficient (<0.6 ppm)
Machenahalli	63	Strongly alkaline (pH 8.4-9.0)	Non Saline (<2 dsm)	Low (<0.5 %)	Medium (23-57 kg/ha)	High (>337 kg/ha)	Medium (10-20 ppm)	Low (<0.5 ppm)	Deficient (<4.5 ppm)	Sufficient (>1.0 ppm)	Sufficient (>0.2 ppm)	Deficient (<0.6 ppm)
Machenahalli	64	Strongly alkaline (pH 8.4-9.0)	Non Saline (<2 dsm)	Medium (0.5-0.75 %)	Medium (23-57 kg/ha)	Medium (145-337 kg/ha)	Medium (10-20 ppm)	Low (<0.5 ppm)	Deficient (<4.5 ppm)	Sufficient (>1.0 ppm)	Sufficient (>0.2 ppm)	Deficient (<0.6 ppm)
Machenahalli	65	Strongly alkaline (pH 8.4-9.0)	Non Saline (<2 dsm)	Medium (0.5-0.75 %)	Medium (23-57 kg/ha)	Medium (145-337 kg/ha)	Medium (10-20 ppm)	Medium (0.5-1.0 ppm)	Deficient (<4.5 ppm)	Sufficient (>1.0 ppm)	Sufficient (>0.2 ppm)	Deficient (<0.6 ppm)
Machenahalli	66	Strongly alkaline (pH 8.4-9.0)	Non Saline (<2 dsm)	Medium (0.5-0.75 %)	Low (<23 kg/ha)	Medium (145-337 kg/ha)	Medium (10-20 ppm)	Medium (0.5-1.0 ppm)	Deficient (<4.5 ppm)	Sufficient (>1.0 ppm)	Sufficient (>0.2 ppm)	Deficient (<0.6 ppm)
Machenahalli	67	Strongly alkaline (pH 8.4-9.0)	Non Saline (<2 dsm)	Medium (0.5-0.75 %)	Low (<23 kg/ha)	Medium (145-337 kg/ha)	Medium (10-20 ppm)	Low (<0.5 ppm)	Deficient (<4.5 ppm)	Sufficient (>1.0 ppm)	Sufficient (>0.2 ppm)	Deficient (<0.6 ppm)
Machenahalli	68	Strongly alkaline (pH 8.4-9.0)	Non Saline (<2 dsm)	Low (<0.5 %)	Low (<23 kg/ha)	Medium (145-337 kg/ha)	Medium (10-20 ppm)	Medium (0.5-1.0 ppm)	Deficient (<4.5 ppm)	Sufficient (>1.0 ppm)	Sufficient (>0.2 ppm)	Deficient (<0.6 ppm)
Machenahalli	69	Moderately alkaline (pH 7.8-8.4)	Non Saline (<2 dsm)	Medium (0.5-0.75 %)	Medium (23-57 kg/ha)	Medium (145-337 kg/ha)	Medium (10-20 ppm)	Low (<0.5 ppm)	Deficient (<4.5 ppm)	Sufficient (>1.0 ppm)	Sufficient (>0.2 ppm)	Deficient (<0.6 ppm)
Machenahalli	70	Strongly alkaline (pH 8.4-9.0)	Non Saline (<2 dsm)	Medium (0.5-0.75 %)	Medium (23-57 kg/ha)	Medium (145-337 kg/ha)	Medium (10-20 ppm)	Low (<0.5 ppm)	Deficient (<4.5 ppm)	Sufficient (>1.0 ppm)	Sufficient (>0.2 ppm)	Deficient (<0.6 ppm)
Machenahalli	71	Moderately alkaline (pH 7.8-8.4)	Non Saline (<2 dsm)	High (>0.75 %)	Medium (23-57 kg/ha)	High (>337 kg/ha)	Medium (10-20 ppm)	Low (<0.5 ppm)	Deficient (<4.5 ppm)	Sufficient (>1.0 ppm)	Sufficient (>0.2 ppm)	Deficient (<0.6 ppm)
Machenahalli	72/1	Strongly alkaline (pH 8.4-9.0)	Non Saline (<2 dsm)	High (>0.75 %)	Low (<23 kg/ha)	High (>337 kg/ha)	Low (<10 ppm)	Medium (0.5-1.0 ppm)	Deficient (<4.5 ppm)	Sufficient (>1.0 ppm)	Sufficient (>0.2 ppm)	Deficient (<0.6 ppm)
Machenahalli	72/2	Strongly alkaline (pH 8.4-9.0)	Non Saline (<2 dsm)	High (>0.75 %)	Low (<23 kg/ha)	High (>337 kg/ha)	Medium (10-20 ppm)	Medium (0.5-1.0 ppm)	Deficient (<4.5 ppm)	Sufficient (>1.0 ppm)	Sufficient (>0.2 ppm)	Deficient (<0.6 ppm)
Machenahalli	73	Strongly alkaline (pH 8.4-9.0)	Non Saline (<2 dsm)	High (>0.75 %)	Low (<23 kg/ha)	High (>337 kg/ha)	Low (<10 ppm)	Medium (0.5-1.0 ppm)	Deficient (<4.5 ppm)	Sufficient (>1.0 ppm)	Sufficient (>0.2 ppm)	Deficient (<0.6 ppm)
Machenahalli	74	Moderately alkaline (pH 7.8-8.4)	Non Saline (<2 dsm)	High (>0.75 %)	Medium (23-57 kg/ha)	High (>337 kg/ha)	Low (<10 ppm)	Medium (0.5-1.0 ppm)	Deficient (<4.5 ppm)	Sufficient (>1.0 ppm)	Sufficient (>0.2 ppm)	Sufficient (>0.6 ppm)
Machenahalli	75	Moderately alkaline (pH 7.8-8.4)	Non Saline (<2 dsm)	High (>0.75 %)	Medium (23-57 kg/ha)	Medium (145-337 kg/ha)	Low (<10 ppm)	Medium (0.5-1.0 ppm)	Deficient (<4.5 ppm)	Sufficient (>1.0 ppm)	Sufficient (>0.2 ppm)	Sufficient (>0.6 ppm)
Machenahalli	76	Slightly alkaline (pH 7.3-7.8)	Non Saline (<2 dsm)	High (>0.75 %)	Medium (23-57 kg/ha)	Medium (145-337 kg/ha)	Low (<10 ppm)	Medium (0.5-1.0 ppm)	Deficient (<4.5 ppm)	Sufficient (>1.0 ppm)	Sufficient (>0.2 ppm)	Sufficient (>0.6 ppm)
Machenahalli	77	Neutral (pH 6.5-7.3)	Non Saline (<2 dsm)	High (>0.75 %)	Low (<23 kg/ha)	Medium (145-337 kg/ha)	Low (<10 ppm)	Low (<0.5 ppm)	Deficient (<4.5 ppm)	Sufficient (>1.0 ppm)	Sufficient (>0.2 ppm)	Sufficient (>0.6 ppm)
Machenahalli	78/1	Neutral (pH 6.5-7.3)	Non Saline (<2 dsm)	High (>0.75 %)	Low (<23 kg/ha)	Medium (145-337 kg/ha)	Low (<10 ppm)	Low (<0.5 ppm)	Deficient (<4.5 ppm)	Sufficient (>1.0 ppm)	Sufficient (>0.2 ppm)	Sufficient (>0.6 ppm)

Village	Survey. No.	Soil Reaction	Salinity	Organic Carbon	Available Phosphorus	Available Potassium	Available Sulphur	Available Boron	Available Iron	Available Manganese	Available Copper	Available Zinc
Machenahalli	78/2	Neutral (pH 6.5-7.3)	Non Saline (<2 dsm)	High (>0.75 %)	Low (<23 kg/ha)	Medium (145-337 kg/ha)	Low (<10 ppm)	Low (<0.5 ppm)	Deficient (<4.5 ppm)	Sufficient (>1.0 ppm)	Sufficient (>0.2 ppm)	Deficient (<0.6 ppm)
Machenahalli	78/3	Neutral (pH 6.5-7.3)	Non Saline (<2 dsm)	High (>0.75 %)	Low (<23 kg/ha)	Medium (145-337 kg/ha)	Low (<10 ppm)	Low (<0.5 ppm)	Deficient (<4.5 ppm)	Sufficient (>1.0 ppm)	Sufficient (>0.2 ppm)	Deficient (<0.6 ppm)
Machenahalli	79	Neutral (pH 6.5-7.3)	Non Saline (<2 dsm)	High (>0.75 %)	Low (<23 kg/ha)	Medium (145-337 kg/ha)	Low (<10 ppm)	Low (<0.5 ppm)	Deficient (<4.5 ppm)	Sufficient (>1.0 ppm)	Sufficient (>0.2 ppm)	Sufficient (>0.6 ppm)
Machenahalli	80	Rock outcrops	Rockout crops	Rock outcrops	Rock outcrops	Rock outcrops	Rock outcrops	Rock outcrops	Rock outcrops	Rock outcrops	Rock outcrops	Rock outcrops
Machenahalli	102	Moderately alkaline (pH 7.8-8.4)	Non Saline (<2 dsm)	High (>0.75 %)	Low (<23 kg/ha)	High (>337 kg/ha)	Low (<10 ppm)	Low (<0.5 ppm)	Deficient (<4.5 ppm)	Sufficient (>1.0 ppm)	Sufficient (>0.2 ppm)	Deficient (<0.6 ppm)
Machenahalli	103	Moderately alkaline (pH 7.8-8.4)	Non Saline (<2 dsm)	High (>0.75 %)	Low (<23 kg/ha)	High (>337 kg/ha)	Low (<10 ppm)	Low (<0.5 ppm)	Deficient (<4.5 ppm)	Sufficient (>1.0 ppm)	Sufficient (>0.2 ppm)	Deficient (<0.6 ppm)
Machenahalli	103/A	Others	Others	Others	Others	Others	Others	Others	Others	Others	Others	Others
Machenahalli	104	Moderately alkaline (pH 7.8-8.4)	Non Saline (<2 dsm)	High (>0.75 %)	Low (<23 kg/ha)	High (>337 kg/ha)	Low (<10 ppm)	Low (<0.5 ppm)	Deficient (<4.5 ppm)	Sufficient (>1.0 ppm)	Sufficient (>0.2 ppm)	Deficient (<0.6 ppm)
Machenahalli	105	Strongly alkaline (pH 8.4-9.0)	Non Saline (<2 dsm)	Low (<0.5 %)	Medium (23-57 kg/ha)	High (>337 kg/ha)	Medium (10-20 ppm)	Low (<0.5 ppm)	Deficient (<4.5 ppm)	Sufficient (>1.0 ppm)	Sufficient (>0.2 ppm)	Deficient (<0.6 ppm)
Machenahalli	106	Strongly alkaline (pH 8.4-9.0)	Non Saline (<2 dsm)	Medium (0.5-0.75 %)	Low (<23 kg/ha)	Medium (145-337 kg/ha)	Medium (10-20 ppm)	Medium (0.5-1.0 ppm)	Deficient (<4.5 ppm)	Sufficient (>1.0 ppm)	Sufficient (>0.2 ppm)	Deficient (<0.6 ppm)
Navebavanura	27	Rock outcrops	Non Saline (<2 dsm)	High (>0.75 %)	Low (<23 kg/ha)	High (>337 kg/ha)	Low (<10 ppm)	Medium (0.5-1.0 ppm)	Deficient (<4.5 ppm)	Sufficient (>1.0 ppm)	Sufficient (>0.2 ppm)	Sufficient (>0.6 ppm)
Navebavanura	28	Moderately alkaline (pH 7.8-8.4)	Non Saline (<2 dsm)	High (>0.75 %)	Low (<23 kg/ha)	High (>337 kg/ha)	Low (<10 ppm)	Medium (0.5-1.0 ppm)	Deficient (<4.5 ppm)	Sufficient (>1.0 ppm)	Sufficient (>0.2 ppm)	Sufficient (>0.6 ppm)
Navebavanura	29	Neutral (pH 6.5-7.3)	Non Saline (<2 dsm)	High (>0.75 %)	Low (<23 kg/ha)	High (>337 kg/ha)	Low (<10 ppm)	Low (<0.5 ppm)	Deficient (<4.5 ppm)	Sufficient (>1.0 ppm)	Sufficient (>0.2 ppm)	Sufficient (>0.6 ppm)
Navebavanura	34	Neutral (pH 6.5-7.3)	Non Saline (<2 dsm)	High (>0.75 %)	Low (<23 kg/ha)	High (>337 kg/ha)	Low (<10 ppm)	Low (<0.5 ppm)	Deficient (<4.5 ppm)	Sufficient (>1.0 ppm)	Sufficient (>0.2 ppm)	Sufficient (>0.6 ppm)
Navebavanura	39	Neutral (pH 6.5-7.3)	Non Saline (<2 dsm)	High (>0.75 %)	Low (<23 kg/ha)	High (>337 kg/ha)	Low (<10 ppm)	Low (<0.5 ppm)	Deficient (<4.5 ppm)	Sufficient (>1.0 ppm)	Sufficient (>0.2 ppm)	Sufficient (>0.6 ppm)
Navebavanura	40	Neutral (pH 6.5-7.3)	Non Saline (<2 dsm)	High (>0.75 %)	Low (<23 kg/ha)	High (>337 kg/ha)	Low (<10 ppm)	Low (<0.5 ppm)	Deficient (<4.5 ppm)	Sufficient (>1.0 ppm)	Sufficient (>0.2 ppm)	Sufficient (>0.6 ppm)
Ranathura	64	Rock outcrops	Rockout crops	Rock outcrops	Rock outcrops	Rock outcrops	Rock outcrops	Rock outcrops	Rock outcrops	Rock outcrops	Rock outcrops	Rock outcrops
Ranathura	65	Neutral (pH 6.5-7.3)	Non Saline (<2 dsm)	Medium (0.5-0.75 %)	Low (<23 kg/ha)	Medium (145-337 kg/ha)	Low (<10 ppm)	Medium (0.5-1.0 ppm)	Sufficient (>4.5 ppm)	Sufficient (>1.0 ppm)	Sufficient (>0.2 ppm)	Deficient (<0.6 ppm)
Ranathura	66	Slightly alkaline (pH 7.3-7.8)	Non Saline (<2 dsm)	High (>0.75 %)	Low (<23 kg/ha)	Medium (145-337 kg/ha)	Medium (10-20 ppm)	Medium (0.5-1.0 ppm)	Deficient (<4.5 ppm)	Sufficient (>1.0 ppm)	Sufficient (>0.2 ppm)	Deficient (<0.6 ppm)
Ranathura	67	Slightly alkaline (pH 7.3-7.8)	Non Saline (<2 dsm)	High (>0.75 %)	Low (<23 kg/ha)	Medium (145-337 kg/ha)	Medium (10-20 ppm)	Low (<0.5 ppm)	Deficient (<4.5 ppm)	Sufficient (>1.0 ppm)	Sufficient (>0.2 ppm)	Deficient (<0.6 ppm)
Ranathura	68	Neutral (pH 6.5-7.3)	Non Saline (<2 dsm)	High (>0.75 %)	Low (<23 kg/ha)	Medium (145-337 kg/ha)	Low (<10 ppm)	Low (<0.5 ppm)	Deficient (<4.5 ppm)	Sufficient (>1.0 ppm)	Sufficient (>0.2 ppm)	Deficient (<0.6 ppm)
Ranathura	69	Neutral (pH 6.5-7.3)	Non Saline (<2 dsm)	High (>0.75 %)	Low (<23 kg/ha)	Medium (145-337 kg/ha)	Medium (10-20 ppm)	Medium (0.5-1.0 ppm)	Deficient (<4.5 ppm)	Sufficient (>1.0 ppm)	Sufficient (>0.2 ppm)	Deficient (<0.6 ppm)
Ranathura	70	Neutral (pH 6.5-7.3)	Non Saline (<2 dsm)	High (>0.75 %)	Low (<23 kg/ha)	Medium (145-337 kg/ha)	Low (<10 ppm)	Medium (0.5-1.0 ppm)	Deficient (<4.5 ppm)	Sufficient (>1.0 ppm)	Sufficient (>0.2 ppm)	Deficient (<0.6 ppm)

Village	Survey. No.	Soil Reaction	Salinity	Organic Carbon	Available Phosphorus	Available Potassium	Available Sulphur	Available Boron	Available Iron	Available Manganese	Available Copper	Available Zinc
Ranathura	71	Neutral (pH 6.5-7.3)	Non Saline (<2 dsm)	High (>0.75 %)	Low (<23 kg/ha)	Medium (145-337 kg/ha)	Low (<10 ppm)	Low (<0.5 ppm)	Deficient (<4.5 ppm)	Sufficient (>1.0 ppm)	Sufficient (>0.2 ppm)	Sufficient (>0.6 ppm)
Ranathura	72	Neutral (pH 6.5-7.3)	Non Saline (<2 dsm)	High (>0.75 %)	Low (<23 kg/ha)	Medium (145-337 kg/ha)	Low (<10 ppm)	Low (<0.5 ppm)	Deficient (<4.5 ppm)	Sufficient (>1.0 ppm)	Sufficient (>0.2 ppm)	Sufficient (>0.6 ppm)
Ranathura	73	Slightly alkaline (pH 7.3-7.8)	Non Saline (<2 dsm)	Medium (0.5-0.75 %)	Low (<23 kg/ha)	Medium (145-337 kg/ha)	Medium (10-20 ppm)	Low (<0.5 ppm)	Deficient (<4.5 ppm)	Sufficient (>1.0 ppm)	Sufficient (>0.2 ppm)	Deficient (<0.6 ppm)
Ranathura	74	Neutral (pH 6.5-7.3)	Non Saline (<2 dsm)	High (>0.75 %)	Low (<23 kg/ha)	Medium (145-337 kg/ha)	Medium (10-20 ppm)	Low (<0.5 ppm)	Deficient (<4.5 ppm)	Sufficient (>1.0 ppm)	Sufficient (>0.2 ppm)	Deficient (<0.6 ppm)
Ranathura	75	Strongly alkaline (pH 8.4-9.0)	Non Saline (<2 dsm)	Medium (0.5-0.75 %)	Low (<23 kg/ha)	Medium (145-337 kg/ha)	Medium (10-20 ppm)	Medium (0.5-1.0 ppm)	Deficient (<4.5 ppm)	Sufficient (>1.0 ppm)	Sufficient (>0.2 ppm)	Deficient (<0.6 ppm)
Ranathura	76	Strongly alkaline (pH 8.4-9.0)	Non Saline (<2 dsm)	Medium (0.5-0.75 %)	Low (<23 kg/ha)	Medium (145-337 kg/ha)	Medium (10-20 ppm)	Medium (0.5-1.0 ppm)	Deficient (<4.5 ppm)	Sufficient (>1.0 ppm)	Sufficient (>0.2 ppm)	Deficient (<0.6 ppm)
Ranathura	77	Strongly alkaline (pH 8.4-9.0)	Non Saline (<2 dsm)	Medium (0.5-0.75 %)	Low (<23 kg/ha)	Medium (145-337 kg/ha)	Medium (10-20 ppm)	Low (<0.5 ppm)	Deficient (<4.5 ppm)	Sufficient (>1.0 ppm)	Sufficient (>0.2 ppm)	Deficient (<0.6 ppm)
Ranathura	78	Strongly alkaline (pH 8.4-9.0)	Non Saline (<2 dsm)	Low (<0.5 %)	Low (<23 kg/ha)	Medium (145-337 kg/ha)	Medium (10-20 ppm)	Low (<0.5 ppm)	Deficient (<4.5 ppm)	Sufficient (>1.0 ppm)	Sufficient (>0.2 ppm)	Deficient (<0.6 ppm)
Ranathura	79	Strongly alkaline (pH 8.4-9.0)	Non Saline (<2 dsm)	Low (<0.5 %)	Low (<23 kg/ha)	Medium (145-337 kg/ha)	Medium (10-20 ppm)	Low (<0.5 ppm)	Deficient (<4.5 ppm)	Sufficient (>1.0 ppm)	Sufficient (>0.2 ppm)	Deficient (<0.6 ppm)
Ranathura	80	Strongly alkaline (pH 8.4-9.0)	Non Saline (<2 dsm)	Medium (0.5-0.75 %)	Medium (23-57 kg/ha)	Medium (145-337 kg/ha)	Medium (10-20 ppm)	Low (<0.5 ppm)	Deficient (<4.5 ppm)	Sufficient (>1.0 ppm)	Sufficient (>0.2 ppm)	Deficient (<0.6 ppm)
Ranathura	82	Neutral (pH 6.5-7.3)	Non Saline (<2 dsm)	Medium (0.5-0.75 %)	Low (<23 kg/ha)	Medium (145-337 kg/ha)	Medium (10-20 ppm)	Medium (0.5-1.0 ppm)	Sufficient (>4.5 ppm)	Sufficient (>1.0 ppm)	Sufficient (>0.2 ppm)	Deficient (<0.6 ppm)
Ranathura	97	Strongly alkaline (pH 8.4-9.0)	Non Saline (<2 dsm)	Medium (0.5-0.75 %)	Medium (23-57 kg/ha)	High (>337 kg/ha)	Medium (10-20 ppm)	Low (<0.5 ppm)	Deficient (<4.5 ppm)	Sufficient (>1.0 ppm)	Sufficient (>0.2 ppm)	Deficient (<0.6 ppm)
Ranathura	98	Strongly alkaline (pH 8.4-9.0)	Non Saline (<2 dsm)	Medium (0.5-0.75 %)	Medium (23-57 kg/ha)	High (>337 kg/ha)	Medium (10-20 ppm)	Low (<0.5 ppm)	Deficient (<4.5 ppm)	Sufficient (>1.0 ppm)	Sufficient (>0.2 ppm)	Deficient (<0.6 ppm)
Ranathura	99	Strongly alkaline (pH 8.4-9.0)	Non Saline (<2 dsm)	High (>0.75 %)	Medium (23-57 kg/ha)	High (>337 kg/ha)	Medium (10-20 ppm)	Low (<0.5 ppm)	Deficient (<4.5 ppm)	Sufficient (>1.0 ppm)	Sufficient (>0.2 ppm)	Deficient (<0.6 ppm)
Ranathura	101	Strongly alkaline (pH 8.4-9.0)	Non Saline (<2 dsm)	High (>0.75 %)	Medium (23-57 kg/ha)	High (>337 kg/ha)	Medium (10-20 ppm)	Low (<0.5 ppm)	Deficient (<4.5 ppm)	Sufficient (>1.0 ppm)	Sufficient (>0.2 ppm)	Deficient (<0.6 ppm)
Ranathura	102	Moderately alkaline (pH 7.8-8.4)	Non Saline (<2 dsm)	High (>0.75 %)	Medium (23-57 kg/ha)	Medium (145-337 kg/ha)	Medium (10-20 ppm)	Low (<0.5 ppm)	Deficient (<4.5 ppm)	Sufficient (>1.0 ppm)	Sufficient (>0.2 ppm)	Deficient (<0.6 ppm)
Ranathura	105	Moderately alkaline (pH 7.8-8.4)	Non Saline (<2 dsm)	High (>0.75 %)	Medium (23-57 kg/ha)	Medium (145-337 kg/ha)	Medium (10-20 ppm)	Low (<0.5 ppm)	Deficient (<4.5 ppm)	Sufficient (>1.0 ppm)	Sufficient (>0.2 ppm)	Deficient (<0.6 ppm)
Ranathura	106	Moderately alkaline (pH 7.8-8.4)	Non Saline (<2 dsm)	Medium (0.5-0.75 %)	Medium (23-57 kg/ha)	Medium (145-337 kg/ha)	Medium (10-20 ppm)	Medium (0.5-1.0 ppm)	Deficient (<4.5 ppm)	Sufficient (>1.0 ppm)	Sufficient (>0.2 ppm)	Deficient (<0.6 ppm)
Ranathura	110	Moderately alkaline (pH 7.8-8.4)	Non Saline (<2 dsm)	Medium (0.5-0.75 %)	Low (<23 kg/ha)	Medium (145-337 kg/ha)	Medium (10-20 ppm)	Low (<0.5 ppm)	Deficient (<4.5 ppm)	Sufficient (>1.0 ppm)	Sufficient (>0.2 ppm)	Deficient (<0.6 ppm)

Appendix III

Machinalli-1 Microwaterhed

Soil Suitability Information

Village	Survey No.	Mango	Maize	Sapota	Sorghum	Guava	Cotton	Tamarind	Lime	Sunflower	Amla	Jackfruit	Custard-apple	Cashew	Jamun	Musambi	Sugarcane	Groundnut	Onion	Chilly	Tomato	Marigold	Chrysanthemum	Pomegranate	Citrus	Bhendi
Machenahalli	1	N	S3t	S3t	S1	S3t	S1	S3t	S2r	S1	S1	N	S1	N	S3t	S2r	S3t	S3t	S3t	S2g	S2rt	S2t	S2t	S2t	S1	S2tw
Machenahalli	2	N	S3t	S3t	S1	S3t	S1	S3t	S2r	S1	S1	N	S1	N	S3t	S2r	S3t	S3t	S3t	S2g	S2rt	S2t	S2t	S2t	S1	S2tw
Machenahalli	3/1	N	S3t	S3t	S1	S3t	S1	S3t	S2r	S1	S1	N	S1	N	S3t	S2r	S3t	S3t	S3t	S2g	S2rt	S2t	S2t	S2t	S1	S2tw
Machenahalli	3/2	N	S3rt	Ntr	S3r	Ntr	S3r	N	N	Nr	S3r	N	S3r	N	N	N	Nrz	S3tr	S3t	S2rg	S2rt	S3rt	S3rt	Nrt	Nr	S3rt
Machenahalli	3/3	N	S3t	S3t	S1	S3t	S1	S3t	S2r	S1	S1	N	S1	N	S3t	S2r	S3t	S3t	S3t	S2g	S2rt	S2t	S2t	S2t	S1	S2tw
Machenahalli	4	Others	Others	Others	Others	Others	Others	Others	Others	Others	Others	Others	Others	Others	Others	Others	Others	Others	Others	Others	Others	Others	Others	Others	Others	Others
Machenahalli	5	N	S3rt	Ntr	S3r	Ntr	S3r	N	N	Nr	S3r	N	S3r	N	N	N	Nrz	S3tr	S3t	S2rg	S2rt	S3rt	S3rt	Nrt	Nr	S3rt
Machenahalli	6	N	S3t	S3t	S1	S3t	S1	S3t	S2r	S1	S1	N	S1	N	S3t	S2r	S3t	S3t	S3t	S2g	S2rt	S2t	S2t	S2t	S1	S2tw
Machenahalli	7	N	S3t	S3t	S1	S3t	S1	S3t	S2r	S1	S1	N	S1	N	S3t	S2r	S3t	S3t	S3t	S2g	S2rt	S2t	S2t	S2t	S1	S2tw
Machenahalli	8	N	S3t	S3t	S1	S3t	S1	S3t	S2r	S1	S1	N	S1	N	S3t	S2r	S3t	S3t	S3t	S2g	S2rt	S2t	S2t	S2t	S1	S2tw
Machenahalli	9	N	S3rg	Nr	S3rg	Nr	S3g	N	N	Nr	S3r	N	S3r	N	N	N	Nr	S3r	S3rg	S3rg	S3rg	S3rg	S3rg	Nr	Nr	S3rg
Machenahalli	10	N	S3t	S3t	S1	S3t	S1	S3t	S2r	S1	S1	N	S1	N	S3t	S2r	S3t	S3t	S3t	S2g	S2rt	S2t	S2t	S2t	S1	S2tw
Machenahalli	11/1	N	S3t	S3t	S1	S3t	S1	S3t	S2r	S1	S1	N	S1	N	S3t	S2r	S3t	S3t	S3t	S2g	S2rt	S2t	S2t	S2t	S1	S2tw
Machenahalli	11/2	N	S3t	S3t	S1	S3t	S1	S3t	S2r	S1	S1	N	S1	N	S3t	S2r	S3t	S3t	S3t	S2g	S2rt	S2t	S2t	S2t	S1	S2tw
Machenahalli	12	N	S3t	S3t	S1	S3t	S1	S3t	S2r	S1	S1	N	S1	N	S3t	S2r	S3t	S3t	S3t	S2g	S2rt	S2t	S2t	S2t	S1	S2tw
Machenahalli	13	N	S3t	S3t	S1	S3t	S1	S3t	S2r	S1	S1	N	S1	N	S3t	S2r	S3t	S3t	S3t	S2g	S2rt	S2t	S2t	S2t	S1	S2tw
Machenahalli	15	N	S3t	S3t	S1	S3t	S1	S3t	S2r	S1	S1	N	S1	N	S3t	S2r	S3t	S3t	S3t	S2g	S2rt	S2t	S2t	S2t	S1	S2tw
Machenahalli	19/A	N	S2rg	S3r	S2rg	S3r	S2r	S3r	N	S3r	S2r	N	S2r	S3r	S3r	N	S3r	S2r	S2rg	S2rg	S2r	S2r	S2r	S3r	S3r	S2r
Machenahalli	19/B	N	S2rg	S3r	S2rg	S3r	S2r	S3r	N	S3r	S2r	N	S2r	S3r	S3r	N	S3r	S2r	S2rg	S2rg	S2r	S2r	S2r	S3r	S3r	S2r
Machenahalli	55	N	S3t	S3t	S1	S3t	S2r	S3t	S3r	S2r	S2r	N	S2r	N	S3t	S3r	S3t	S3t	S3t	S2g	S2rt	S2t	S2t	S2t	S2r	S2tw
Machenahalli	56	N	S3rt	S3rt	S2r	S3r	S2r	S3rt	N	S3r	S2r	N	S2r	N	S3rt	N	S3t	S3t	S3t	S2r	S2rt	S2t	S2t	S2t	S3r	S2rt
Machenahalli	57	N	S3rt	S3rt	S2r	S3r	S2r	S3rt	N	S3r	S2r	N	S2r	N	S3rt	N	S3t	S3t	S3t	S2r	S2rt	S2t	S2t	S2t	S3r	S2rt
Machenahalli	58	N	S3rt	S3rt	S2r	S3r	S2r	S3rt	N	S3r	S2r	N	S2r	N	S3rt	N	S3t	S3t	S3t	S2r	S2rt	S2t	S2t	S2t	S3r	S2rt
Machenahalli	59	N	S3rt	S3rt	S2r	S3r	S2r	S3rt	N	S3r	S2r	N	S2r	N	S3rt	N	S3t	S3t	S3t	S2r	S2rt	S2t	S2t	S2t	S3r	S2rt
Machenahalli	60/1	N	S3t	S3t	S1	S3t	S1	S3t	S2r	S1	S1	N	S1	N	S3t	S2r	S3t	S3t	S3t	S2g	S2rt	S2t	S2t	S2t	S1	S2tw

Village	Survey No.	Mango	Maize	Sapota	Sorghum	Guava	Cotton	Tamarind	Lime	Sunflower	Amla	Jackfruit	Custard-apple	Cashew	Jamun	Musambi	Sugarcane	Groundnut	Onion	Chilly	Tomato	Marigold	Chrysanthemum	Pomegranate	Citrus	Bhendi
Machenahalli	60/2	N	S3t	S3t	S1	S3t	S2r	S3t	S3r	S2r	S2r	N	S2r	N	S3t	S3r	S3t	S3t	S3t	S2g	S2rt	S2t	S2t	S2t	S2r	S2tw
Machenahalli	61	N	S3t	S3t	S1	S3t	S1	S3t	S2r	S1	S1	N	S1	N	S3t	S2r	S3t	S3t	S3t	S2g	S2rt	S2t	S2t	S2t	S1	S2tw
Machenahalli	62	N	S3rt	S3rt	S2r	S3r	S2r	S3rt	N	S3r	S2r	N	S2r	N	S3rt	N	S3t	S3t	S3t	S2r	S2rt	S2t	S2t	S2t	S3r	S2rt
Machenahalli	63	N	S3rt	S3rt	S2r	S3r	S2r	S3rt	N	S3r	S2r	N	S2r	N	S3rt	N	S3t	S3t	S3t	S2r	S2rt	S2t	S2t	S2t	S3r	S2rt
Machenahalli	64	N	S3rt	S3rt	S2r	S3r	S2r	S3rt	N	S3r	S2r	N	S2r	N	S3rt	N	S3t	S3t	S3t	S2r	S2rt	S2t	S2t	S2t	S3r	S2rt
Machenahalli	65	N	S3rt	Ntr	S3r	Ntr	S3r	N	N	Nr	S3r	N	S3r	N	N	N	Nrz	S3tr	S3t	S2rg	S2rt	S3rt	S3rt	Nrt	Nr	S3rt
Machenahalli	66	N	S3rt	Ntr	S3r	Ntr	S3r	N	N	Nr	S3r	N	S3r	N	N	N	Nrz	S3tr	S3t	S2rg	S2rt	S3rt	S3rt	Nrt	Nr	S3rt
Machenahalli	67	N	S3rt	Ntr	S3r	Ntr	S3r	N	N	Nr	S3r	N	S3r	N	N	N	Nrz	S3tr	S3t	S2rg	S2rt	S3rt	S3rt	Nrt	Nr	S3rt
Machenahalli	68	N	S3t	S3t	S1	S3t	S1	S3t	S2r	S1	S1	N	S1	N	S3t	S2r	S3t	S3t	S3t	S2g	S2rt	S2t	S2t	S2t	S1	S2tw
Machenahalli	69	N	S3t	S3t	S1	S3t	S1	S3t	S2r	S1	S1	N	S1	N	S3t	S2r	S3t	S3t	S3t	S2g	S2rt	S2t	S2t	S2t	S1	S2tw
Machenahalli	70	N	S3zt	Nr	S3z	Nr	S3z	N	N	Nrz	S3r	N	S3r	N	N	N	Nrz	S3zt	S3tz	S2gz	S2tz	S3zt	S3zt	Nrz	Nr	S3tz
Machenahalli	71	N	S3zt	Nr	S3z	Nr	S3z	N	N	Nrz	S3r	N	S3r	N	N	N	Nrz	S3zt	S3tz	S2gz	S2tz	S3zt	S3zt	Nrz	Nr	S3tz
Machenahalli	72/1	N	S3rg	Nr	S3rg	Nr	S3g	N	N	Nr	S3r	N	S3r	N	N	N	Nr	S3r	S3rg	S3rg	S3rg	S3rg	S3rg	Nr	Nr	S3rg
Machenahalli	72/2	N	S3t	S3t	S1	S3t	S1	S3t	S2r	S1	S1	N	S1	N	S3t	S2r	S3t	S3t	S3t	S2g	S2rt	S2t	S2t	S2t	S1	S2tw
Machenahalli	73	N	S3rg	Nr	S3rg	Nr	S3g	N	N	Nr	S3r	N	S3r	N	N	N	Nr	S3r	S3rg	S3rg	S3rg	S3rg	S3rg	Nr	Nr	S3rg
Machenahalli	74	N	S3zt	Nr	S3z	Nr	S3z	N	N	Nrz	S3r	N	S3r	N	N	N	Nrz	S3zt	S3tz	S2gz	S2tz	S3zt	S3zt	Nrz	Nr	S3tz
Machenahalli	75	N	S3zt	Nr	S3z	Nr	S3z	N	N	Nrz	S3r	N	S3r	N	N	N	Nrz	S3zt	S3tz	S2gz	S2tz	S3zt	S3zt	Nrz	Nr	S3tz
Machenahalli	76	N	S3zt	Nr	S3z	Nr	S3z	N	N	Nrz	S3r	N	S3r	N	N	N	Nrz	S3zt	S3tz	S2gz	S2tz	S3zt	S3zt	Nrz	Nr	S3tz
Machenahalli	77	N	S3zt	Nr	S3z	Nr	S3z	N	N	Nrz	S3r	N	S3r	N	N	N	Nrz	S3zt	S3tz	S2gz	S2tz	S3zt	S3zt	Nrz	Nr	S3tz
Machenahalli	78/1	N	S3zt	Nr	S3z	Nr	S3z	N	N	Nrz	S3r	N	S3r	N	N	N	Nrz	S3zt	S3tz	S2gz	S2tz	S3zt	S3zt	Nrz	Nr	S3tz
Machenahalli	78/2	N	S3zt	Nr	S3z	Nr	S3z	N	N	Nrz	S3r	N	S3r	N	N	N	Nrz	S3zt	S3tz	S2gz	S2tz	S3zt	S3zt	Nrz	Nr	S3tz
Machenahalli	78/3	N	S3zt	Nr	S3z	Nr	S3z	N	N	Nrz	S3r	N	S3r	N	N	N	Nrz	S3zt	S3tz	S2gz	S2tz	S3zt	S3zt	Nrz	Nr	S3tz
Machenahalli	79	N	S3zt	Nr	S3z	Nr	S3z	N	N	Nrz	S3r	N	S3r	N	N	N	Nrz	S3zt	S3tz	S2gz	S2tz	S3zt	S3zt	Nrz	Nr	S3tz
Machenahalli	80	Rock out crop	Rock out crops	Rock out crops	Rock out crops	Rock out crops	Rock out crops	Rock out crop	Rock Out crop	Rock out crops	Rock out crop	Rock out crop	Rock out crop	Rock out crop	Rock out crop	Rock out crop	Rock out crops	Rock out crops	Rock out crops	Rock out crops	Rock out crops	Rock out crops	Rock out crops	Rock out crops	Rock out crops	Rock out crop

Village	Survey No.	Mango	Maize	Sapota	Sorgham	Guava	Cotton	Tamarind	Lime	Sunflower	Amla	Jackfruit	Custard-apple	Cashew	Jamun	Musambi	Sugarcane	Groundnut	Onion	Chilly	Tomato	Marigold	Chrysanthemum	Pomegranate	Citrus	Bhendi
Machenahalli	102	N	S3rt	Ntr	S3r	Ntr	S3r	N	N	Nrg	S3r	N	S3r	N	N	N	Nrz	S3tr	S3t	S2rg	S2rt	S3rt	S3rt	Nrt	Nr	S3rt
Machenahalli	103	N	S3rt	Ntr	S3r	Ntr	S3r	N	N	Nrg	S3r	N	S3r	N	N	N	Nrz	S3tr	S3t	S2rg	S2rt	S3rt	S3rt	Nrt	Nr	S3rt
Machenahalli	103/A	Others	Others	Others	Others	Others	Others	Others	Others	Others	Others	Others	Others	Others	Others	Others	Others	Others	Others	Others	Others	Others	Others	Others	Others	Others
Machenahalli	104	N	S3t	S3t	S1	S3t	S1	S3t	S2r	S1	S1	N	S1	N	S3t	S2r	S3t	S3t	S3t	S2g	S2rt	S2t	S2t	S2t	S1	S2tw
Machenahalli	105	N	S3rt	S3rt	S2r	S3r	S2r	S3rt	N	S3r	S2r	N	S2r	N	S3rt	N	S3t	S3t	S3t	S2r	S2rt	S2t	S2t	S2t	S3r	S2rt
Machenahalli	106	N	S3t	S3t	S1	S3t	S1	S3t	S2r	S1	S1	N	S1	N	S3t	S2r	S3t	S3t	S3t	S2g	S2rt	S2t	S2t	S2t	S1	S2tw
Navebavanura	27	N	S2rg	S3r	S2rg	S3r	S2r	S3r	N	S3r	S2r	N	S2r	S3r	S3r	N	S3r	S2r	S2rg	S2rg	S2r	S2r	S2r	S3r	S3r	S2r
Navebavanura	28	N	S2rg	S3r	S2rg	S3r	S2r	S3r	N	S3r	S2r	N	S2r	S3r	S3r	N	S3r	S2r	S2rg	S2rg	S2r	S2r	S2r	S3r	S3r	S2r
Navebavanura	29	N	S2rg	S3r	S2rg	S3r	S2r	S3r	N	S3r	S2r	N	S2r	S3r	S3r	N	S3r	S2r	S2rg	S2rg	S2r	S2r	S2r	S3r	S3r	S2r
Navebavanura	34	N	S2rg	S3r	S2rg	S3r	S2r	S3r	N	S3r	S2r	N	S2r	S3r	S3r	N	S3r	S2r	S2rg	S2rg	S2r	S2r	S2r	S3r	S3r	S2r
Navebavanura	39	N	S2rg	S3r	S2rg	S3r	S2r	S3r	N	S3r	S2r	N	S2r	S3r	S3r	N	S3r	S2r	S2rg	S2rg	S2r	S2r	S2r	S3r	S3r	S2r
Navebavanura	40	N	S2rg	S3r	S2rg	S3r	S2r	S3r	N	S3r	S2r	N	S2r	S3r	S3r	N	S3r	S2r	S2rg	S2rg	S2r	S2r	S2r	S3r	S3r	S2r
Ranathura	64	Rock out crop	Rock out crops	Rock out crops	Rock out crops	Rock out crops	Rock out crops	Rock out crop	Rock Out crop	Rock out crops	Rock out crop	Rock out crop	Rock out crop	Rock out crop	Rock out crop	Rock out crop	Rock out crops	Rock out crops	Rock out crops	Rock out crops	Rock out crops	Rock out crops	Rock out crops	Rock out crops	Rock out crops	Rock out crop
Ranathura	65	N	S3r	Nr	S3r	Nr	S3r	N	N	Nr	S3r	N	S3r	N	N	N	Nr	S3r	S3r	S3r	S3r	S3r	S3r	Nr	Nr	S3rg
Ranathura	66	N	S3r	Nr	S3r	Nr	S3r	N	N	Nr	S3r	N	S3r	N	N	N	Nr	S3r	S3r	S3r	S3r	S3r	S3r	Nr	Nr	S3rg
Ranathura	67	N	S3r	Nr	S3r	Nr	S3r	N	N	Nr	S3r	N	S3r	N	N	N	Nr	S3r	S3r	S3r	S3r	S3r	S3r	Nr	Nr	S3rg
Ranathura	68	N	S3r	Nr	S3r	Nr	S3r	N	N	Nr	S3r	N	S3r	N	N	N	Nr	S3r	S3r	S3r	S3r	S3r	S3r	Nr	Nr	S3rg
Ranathura	69	N	S3r	Nr	S3r	Nr	S3r	N	N	Nr	S3r	N	S3r	N	N	N	Nr	S3r	S3r	S3r	S3r	S3r	S3r	Nr	Nr	S3rg
Ranathura	70	N	S3r	Nr	S3r	Nr	S3r	N	N	Nr	S3r	N	S3r	N	N	N	Nr	S3r	S3r	S3r	S3r	S3r	S3r	Nr	Nr	S3rg
Ranathura	71	N	S3r	Nr	S3r	Nr	S3r	N	N	Nr	S3r	N	S3r	N	N	N	Nr	S3r	S3r	S3r	S3r	S3r	S3r	Nr	Nr	S3rg
Ranathura	72	N	S3r	Nr	S3r	Nr	S3r	N	N	Nr	S3r	N	S3r	N	N	N	Nr	S3r	S3r	S3r	S3r	S3r	S3r	Nr	Nr	S3rg
Ranathura	73	N	S3tg	S3tg	S2g	S3tg	S2rg	S3t	S3r	S2rg	S2r	N	S2r	N	S3t	S3r	S3tg	S3tg	S3tg	S2g	S2rt	S2tg	S2tg	S2tg	S2rg	S2tw
Ranathura	74	N	S2rg	S3r	S2rg	S3r	S2rg	S3r	N	S2rg	S3r	N	S2r	S3r	S3r	N	S3r	S2r	S2rg	S2rg	S2r	S2r	S2r	S3r	S3r	S2r
Ranathura	75	N	S2rg	S3r	S2rg	S3r	S2rg	S3r	N	S2rg	S3r	N	S2r	S3r	S3r	N	S3r	S2r	S2rg	S2rg	S2r	S2r	S2r	S3r	S3r	S2r
Ranathura	76	N	S3t	S3t	S1	S3t	S1	S3t	S2r	S1	S1	N	S1	N	S3t	S2r	S3t	S3t	S3t	S2g	S2rt	S2t	S2t	S2t	S1	S2tw

Village	Survey No.	Mango	Maize	Sapota	Sorghum	Guava	Cotton	Tamarind	Lime	Sunflower	Amla	Jackfruit	Custard-apple	Cashew	Jamun	Musambi	Sugarcane	Groundnut	Onion	Chilly	Tomato	Marigold	Chrysanthemum	Pomegranate	Citrus	Bhendi
Ranathura	77	N	S3t	S3t	S1	S3t	S1	S3t	S2r	S1	S1	N	S1	N	S3t	S2r	S3t	S3t	S3t	S2g	S2rt	S2t	S2t	S2t	S1	S2tw
Ranathura	78	N	S3t	S3t	S1	S3t	S1	S3t	S2r	S1	S1	N	S1	N	S3t	S2r	S3t	S3t	S3t	S2g	S2rt	S2t	S2t	S2t	S1	S2tw
Ranathura	79	N	S3t	S3t	S1	S3t	S1	S3t	S2r	S1	S1	N	S1	N	S3t	S2r	S3t	S3t	S3t	S2g	S2rt	S2t	S2t	S2t	S1	S2tw
Ranathura	80	N	S3t	S3t	S1	S3t	S1	S3t	S2r	S1	S1	N	S1	N	S3t	S2r	S3t	S3t	S3t	S2g	S2rt	S2t	S2t	S2t	S1	S2tw
Ranathura	82	S2gr	S2g	S2g	S2g	S2g	S2rg	S2gr	S2gr	S3g	S2g	S2gr	S2g	S2gr	S2gr	S2gr	S3g	S2gt	S2g	S2g	S2g	S2g	S2g	S2rg	S2g	S2gl
Ranathura	97	N	S3t	S3t	S1	S3t	S1	S3t	S2r	S1	S1	N	S1	N	S3t	S2r	S3t	S3t	S3t	S2g	S2rt	S2t	S2t	S2t	S1	S2tw
Ranathura	98	N	S3t	S3t	S1	S3t	S1	S3t	S2r	S1	S1	N	S1	N	S3t	S2r	S3t	S3t	S3t	S2g	S2rt	S2t	S2t	S2t	S1	S2tw
Ranathura	99	N	S3t	S3t	S1	S3t	S1	S3t	S2r	S1	S1	N	S1	N	S3t	S2r	S3t	S3t	S3t	S2g	S2rt	S2t	S2t	S2t	S1	S2tw
Ranathura	101	N	S3t	S3t	S1	S3t	S1	S3t	S2r	S1	S1	N	S1	N	S3t	S2r	S3t	S3t	S3t	S2g	S2rt	S2t	S2t	S2t	S1	S2tw
Ranathura	102	N	S3t	S3t	S1	S3t	S1	S3t	S2r	S1	S1	N	S1	N	S3t	S2r	S3t	S3t	S3t	S2g	S2rt	S2t	S2t	S2t	S1	S2tw
Ranathura	105	N	S3t	S3t	S1	S3t	S1	S3t	S2r	S1	S1	N	S1	N	S3t	S2r	S3t	S3t	S3t	S2g	S2rt	S2t	S2t	S2t	S1	S2tw
Ranathura	106	N	S3t	S3t	S1	S3t	S1	S3t	S2r	S1	S1	N	S1	N	S3t	S2r	S3t	S3t	S3t	S2g	S2rt	S2t	S2t	S2t	S1	S2tw
Ranathura	110	N	S3t	S3t	S1	S3t	S2r	S3t	S3r	S2r	S2r	N	S2r	N	S3t	S3r	S3t	S3t	S3t	S2g	S2rt	S2t	S2t	S2t	S2r	S2tw

PART-B

SOCIO-ECONOMIC STATUS OF FARM HOUSEHOLDS

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Chapter 1

EXECUTIVE SUMMARY

Baseline socioeconomic characterisation is prerequisite to prepare action plan for program implementation and to assess the project performance before making any changes in the watershed development program. The baseline provides appropriate policy direction for enhancing productivity and sustainability in agriculture.

Methodology: *Machinahalli-1 micro-watershed (Hadgali sub-watershed, Shirahatti Taluk, Gadag district) is located in between $15^0 6'$ – $15^0 8'$ North latitudes and $75^0 38'$ – $75^0 40'$ East longitudes, covering an area of about 712 ha, bounded by Majjur village on north, Rantur village on the west, Nave bavanur village on the south and Machinahalli village on the east with length of growing period (LGP) 150-180 days. We used soil resource map as basis for sampling farm households to test the hypothesis that soil quality influence crop selection, and conservation investment of farm households. The level of technology adoption and productivity gaps and livelihood patterns were analyses. The cost of soil degradation and ecosystem services were quantified.*

Results: *The socio-economic outputs for the Machinahalli-1 Microwatershed (Hadgali sub-watershed, Shirahatti Taluk, Gadag district) are presented here.*

Social Indicators;

- *Male and female ratio is 54 to 46 per cent to the total sample population.*
- *Younger age 18 to 50 years group of population is around 64 per cent to the total population.*
- *Literacy population is around 58 per cent.*
- *Social groups belong to other backward caste (OBC) is around 80 per cent.*
- *Fire wood is the source of energy for a cooking among 60 per cent.*
- *About 20 per cent of households have a yashaswini health card.*
- *Majority of farm households (60%) are having MGNREGA card for rural employment.*
- *Dependence on ration cards for food grains through public distribution system is around 80 per cent.*
- *Swach bharath program providing closed toilet facilities around 50.0 per cent of sample households.*
- *Women participation in decisions making are around 77.8 percent of sample household.*

Economic Indicators;

- *The average land holding is 1.3 ha indicates that majority of farm households are belong to small and medium farmers. The dry land accounted for 68.3 per*

cent and irrigated land is 31.7 per cent of total cultivated land among the sample households.

- *Agriculture is the main occupation among 38 per cent and agriculture is the main and agriculture labour is subsidiary occupation of 56.0 per cent of sample households.*
- *The average value of domestic assets is around Rs. 34707 per household. Mobile and television are popular media mass communication.*
- *The average value of farm assets is around Rs. 80279 per household, about 40 per cent of sample farmers having plough and tractor.*
- *The average value of livestock is around Rs. 24458 per household; about 63 per cent of household are having livestock.*
- *The average per capita food consumption is around 841 grams (1760.5 kilo calories) against national institute of nutrition (NIN) recommendation at 827 gram. Around 90 per cent of sample households are consuming less than the NIN recommendation.*
- *The annual average income is around Rs. 16091 per household. About 90 per cent of farm households are below poverty line.*
- *The per capita average monthly expenditure is around Rs.1124.*

Environmental Indicators-Ecosystem Services;

- *The value of ecosystem service helps to support investment to decision on soil and water conservation and in promoting sustainable land use.*
- *The onsite cost of different soil nutrients lost due to soil erosion is around Rs. 1985 per ha/year. The total cost of annual soil nutrients is around Rs. 1137336 per year for the total area of 711.8 ha.*
- *The average value of ecosystem service for food grain production is around Rs. 8160/ ha/year. Per hectare food grain production services is maximum in onion (Rs. 19170) followed by cotton (Rs. 10469), maize (Rs. 8271), groundnut (Rs. 3036) and sunflower is negative returns.*
- *The average value of ecosystem service for fodder production is around Rs. 1473/ ha/year in maize.*
- *The data on water requirement for producing one quintal of grain is considered for estimating the total value of water required for crop production. The per hectare value of water used and value of water was maximum in cotton (Rs. 46721) followed by maize (Rs. 32336), sunflower (Rs. 29099), groundnut (Rs. 23950) and onion (Rs. 22395).*

Economic Land Evaluation

- *The major cropping pattern is maize (50.8 %) followed by groundnut (20.8 %), cotton (13.9 %), onion (11.2 %) and sunflower (3.3 %).*

- *In Machinahalli-1 micro-watershed, major soil Nabhapur Tanda (NPT) series is having shallow soil depth cover around 5.5 % of area. On this soil farmers are presently growing maize (62.5 %) and groundnut (37.5 %), Yelisirunj (YSJ) and Kaggalipura (KGP) are also having shallow soil depth cover around 6.4 % and 21.8 % of area, respectively; the crops are maize, groundnut, onion and sunflower. Kethanapura (KTP) and Attikatti (ATT) soil series having moderately deep soil depth cover around 6.1 % and 6.3 % of areas, respectively. The major crops are cotton, onion and maize. Jelligeri (JLG) soil series having moderately deep soil depth cover around 6.2 % of area, crops are maize. Mahalingapuratanda (MPT) soil series are having deep soil depth cover around 22.4 % of area; the major crops grown are groundnut and maize.*
- *The data on cost of cultivation and benefit cost ratio (BCR) for groundnut range between Rs. 43075/ha in KGP soil (with BCR of 1.2) and Rs. 26129/ha in MPT soil (with BCR of 1.2).*
- *In maize the cost of cultivation ranges between Rs. 37780/ha in KGP soil (with BCR of 1.3) and Rs. 20714/ha in MPT soil (with BCR of 1.10).*
- *In onion the cost of cultivation range between is Rs 61558/ha in NPT soil (with of 1.18) and Rs 55633 in ATT soil (with BCR of 1.2).*
- *In sunflower the cost of cultivation in KGP soil is Rs. 39049/ha (with BCR of 1.0) and cotton the cost of cultivation in KTP soil Rs. 24320/ha (with BCR of 1.4).*
- *The land management practices reported by the farmers are crop rotation, tillage practices, fertilizer application and use of farm yard manure (FYM). Due to higher wages farmer are following labour saving strategies is not prating soil and water conservation measures. Less ownership of livestock limiting application of FYM.*
- *It was observed soil quality influences on the type and intensity of land use. More fertilizer applications in deeper soil to maximize returns.*

Suggestions;

- *Involving farmers is watershed planning helps in strengthing institutional participation.*
- *The per capita food consumption and monthly income is very low. Diversifying income generation activities from crop and livestock production in order to reduce risk related to drought and market prices.*
- *Majority of farmers reported that they are not getting timely support/extension services from the concerned development departments.*
- *By strengthing agricultural extension for providing timely advice improved technology there is scope to increase in net income of farm households.*

- *By adopting recommended package of practices by following the soil test fertiliser recommendation, there is scope to increase yield in groundnut (46.1 to 56.6 %), onion (49.4 to 74.7 %), maize (40.5 to 77.9 %), sunflower (46.9 %) and cotton (32.1 %).*

Chapter 2

INTRODUCTION

Watershed Development program aim to restore degraded watersheds in rainfed regions to increase their capacity to capture and store rain water, reduce soil erosion, and improved soil nutrients and carbon contents so they can produce greater agricultural yields and other benefits. As majority of rural poor live in these regions and dependent on natural resources for their livelihood and sustenance, improvements in agricultural yields improve human welfare and simultaneously improve national food security.

Sujala–III watershed development project conceptualised and implemented by the Watershed Development Department of Government of Karnataka with tripartite cost-sharing arrangements. The World Bank through International Development Association provided major portion of plan outlay as a loan to Government of India and in turn loan to Government of Karnataka.

The objectives of Sujala-III is to demonstrate more effective watershed management through greater integration of programs related to rain fed agriculture, innovative and science based approaches and strengthened institutions and capacities. The project is implemented in 11 districts of Bidar, Vijayapura, Gulbarga, Yadgir, Koppal, Gadag, Raichur, Davanagere, Tumkur, Chikkamangalur and Chamarajanagar which have been identified by the Watershed Development Department based on rainfall and socio-economic conditions. The project will be implemented over six years and linked with the centrally financed integrated watershed management programme.

Economic evaluations can better guide in watershed planning and implementation, as well as raise awareness of benefits of ecosystem restoration for food security and poverty alleviation program. The present study aims to characterize socio-economic status of farm households, assess the land and water use status, evaluate the economic viability of land use, prioritize farming constraints and suggest the measures for soil and water conservation for sustainable agriculture.

Objectives of the study

1. To characterize socio-economic status of farm households

2. To evaluate the economic viability of land use and land related constraints

3. To estimate the ecosystem service provided by the watershed and

4. To suggest alternatives for sustainable agriculture production.

Chapter 3

METHODOLOGY

Study area

Machinahalli-1 micro-watershed is located in Northern Transition Zone of Karnataka **(**Figure 1). Extends over all area of 1.13 M ha of which 0.86 M ha is under cultivation. Nearly 0.052 M ha in the zone enjoys irrigation facilities. Elevation ranges between 450-900 m MSL with most parts situated between 800 and 900 m. Shallow to black soils and red loams are distributed in equal proportion. The average annual rainfall ranges from 620 to 1300 mm of which more than 60 per cent is received during the southwest monsoon (*kharif*). Sorghum, rice, groundnut, maize, chilli, pulses, sugarcane, tobacco and cotton are the major crops grown. It's represents Agro Ecological Sub Region (AESR) 6.4 having LGP 150-180 days.

Machinahalli-1 micro-watershed (Hadgali sub-watershed, Shirahatti Taluk, Gadag district) is located in between $15^0$6' – $15^0$8' North latitudes and $75^0$38' – $75^0$40' East longitudes, covering an area of about 712 ha, bounded by Majjur village on north, Rantur village on the west, Nave bavanur village on the south, and Machinahalli village on the east.

Sampling Procedure:

In this study we have followed soil variability as criterion for sampling the farm households. In each micro-watershed the survey numbers and associated soil series are listed. Minimum three farm households for each soil series were taken and summed up to arrive at total sample for analysis.

Sources of data and analysis:

For evaluating the specific objectives of the study, primary data was collected from the sample respondents by personal interview method with the help of pre-tested questionnaire. The data on socio-economic characteristics of respondents such as family size and composition, land holdings, asset position, occupational pattern and education level was collected. The present cropping pattern and the level of input use and yields collected during survry. The data collected from the representative farm households were analysed using Automated Land Potential Evalution System (Figure 2).

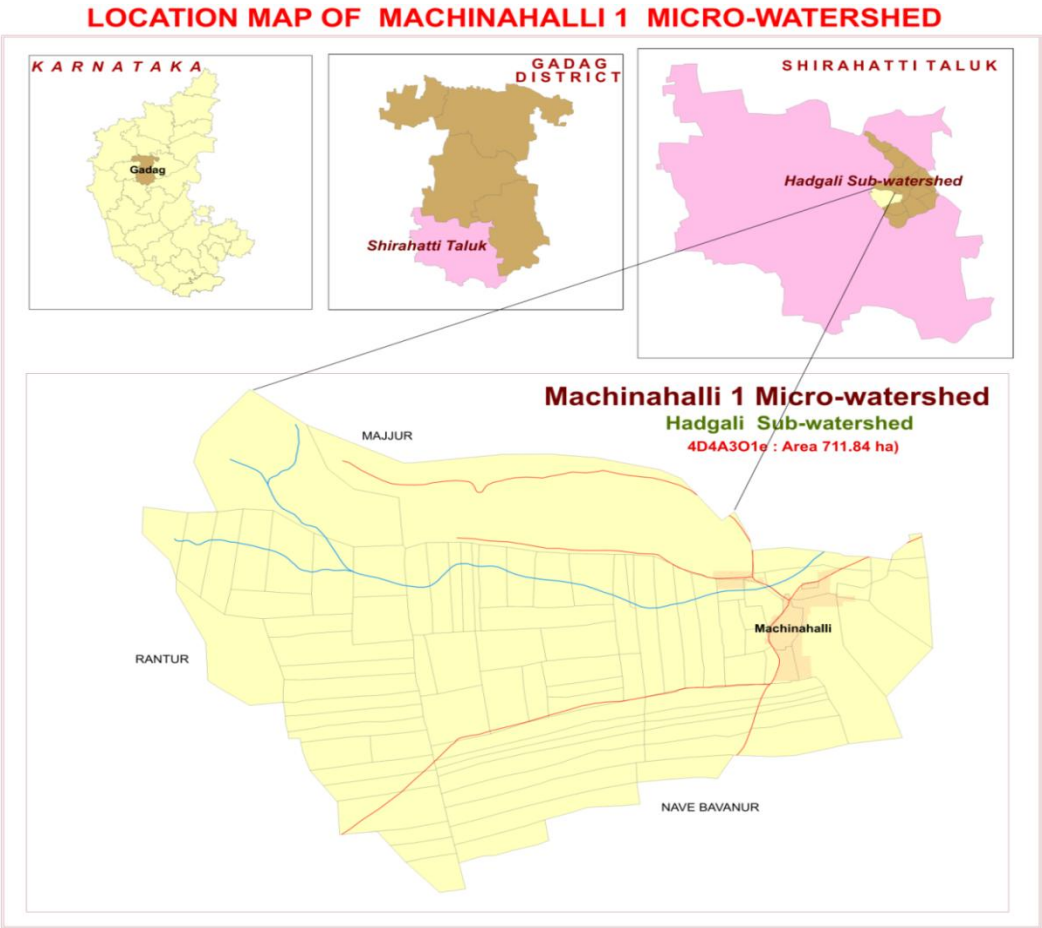
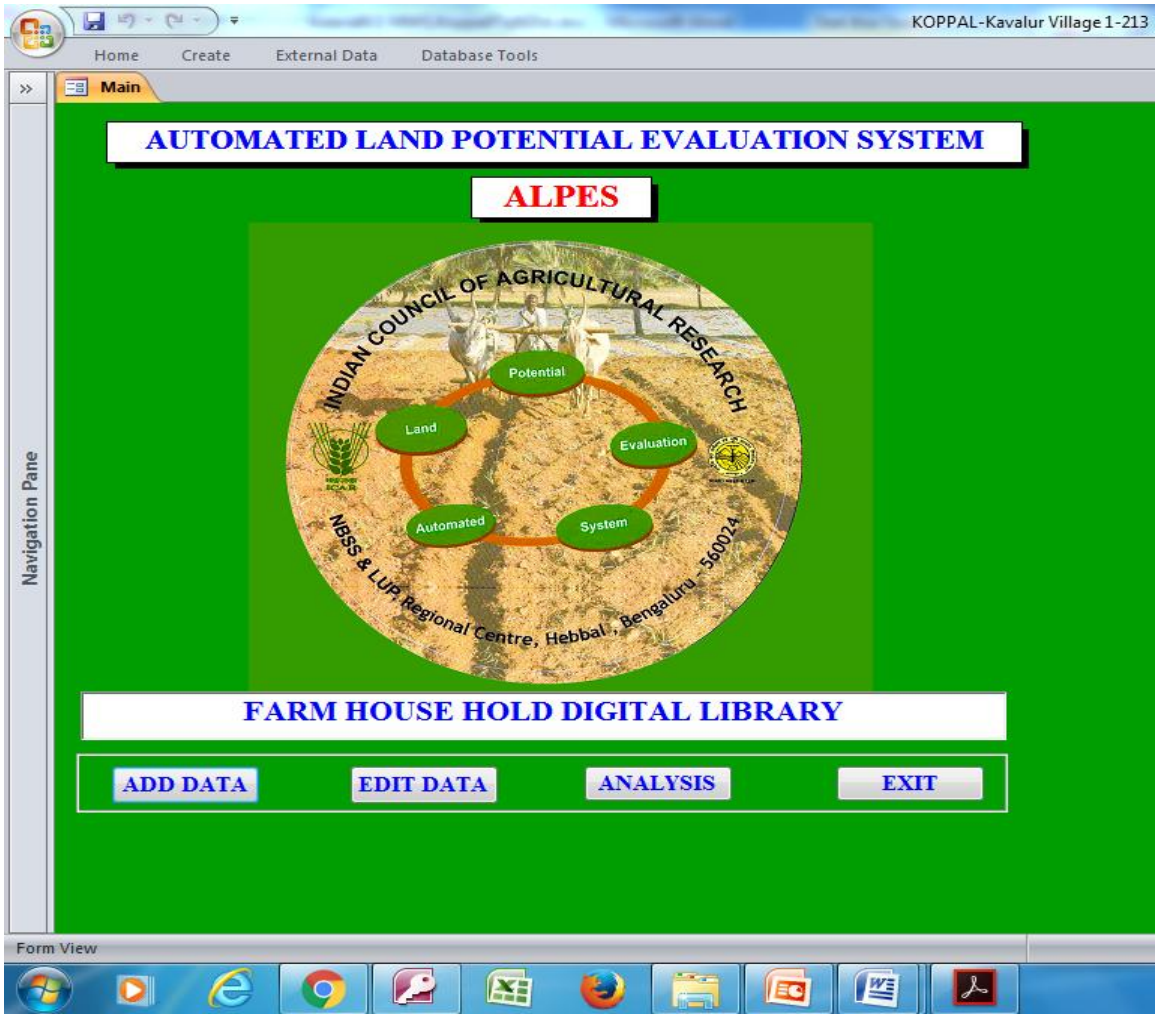


Figure 1: Location of study area

Steps followed in socio-economic assessment

1. •After the completion of soil profile study link the cadastral number to the soil profile in the micro watershed.
2. • Download the names of the farmers who are owning the land for each cadastral number in the Karnataka BHOOMI Website.
3. • Compiling the names of the farmers representing for all the soil profiles studied in the micro watershed for socio-economic Survey.
4. • Conducting the socioeconomic survey of selected farm households in the micro watershed.
5. • Farm households database created using the Automated Land Potential Evaluation System (ALPES) for analysis of socio economic status for each micro watershed.
6. • Synthesis of tables and preparation of report for each micro watershed.



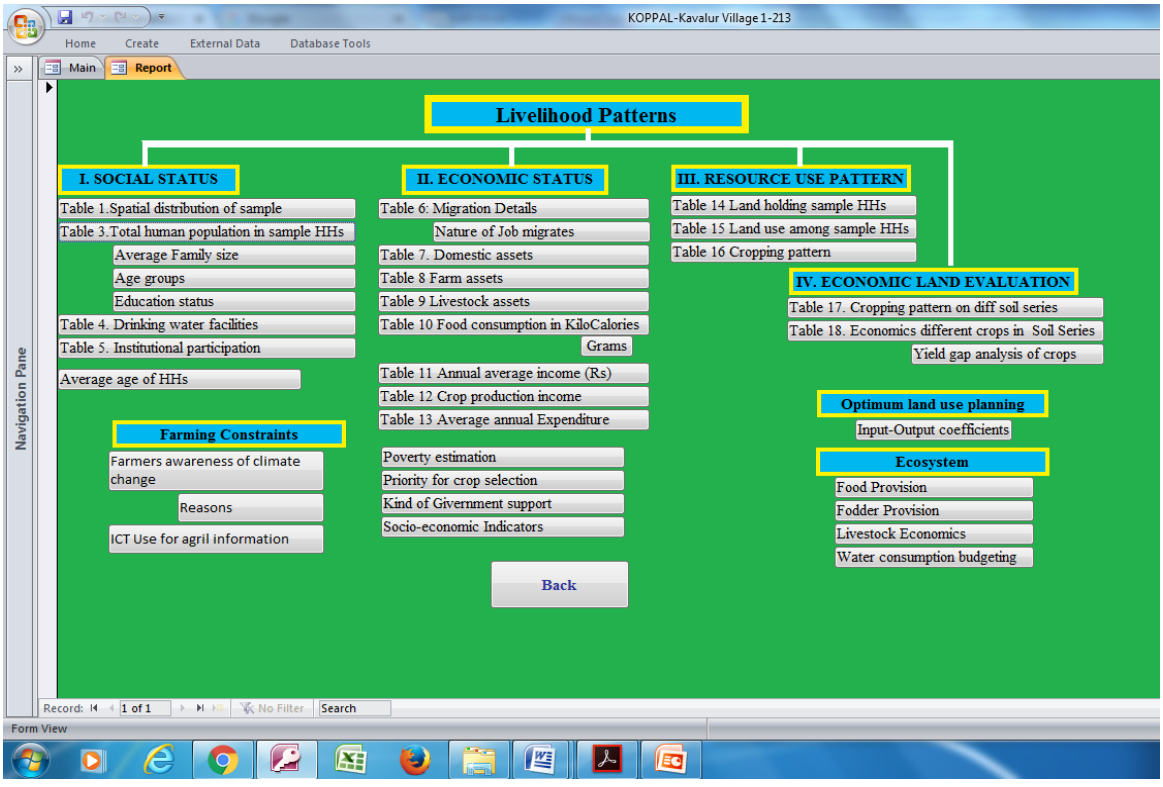


Figure 2: ALPES FRAMEWORK

The sample farmers were post classified in to marginal and small (0.0 to <=2 ha), medium and semi medium (>2 to <=10 ha) and large (>10 ha). The steps involved in estimation of soil potential involve estimation of total cost of cultivation, the yield/gross returns and net income per hectare. The cost of inputs such seed, manure and fertilizer, plant protection chemicals, payment towards human and bullock labour and interest on working capita are included under operational costs. In the case of perennial crops, the cost of establishment was estimated by using actual physical requirements and prevailing market prices. Estimation cost included maintenance cost up to bearing period. The value of main product and by product from the crop enterprise at the market rates were the gross returns of the crop. Net returns were worked out by deducting establishment and maintained cost from gross returns.

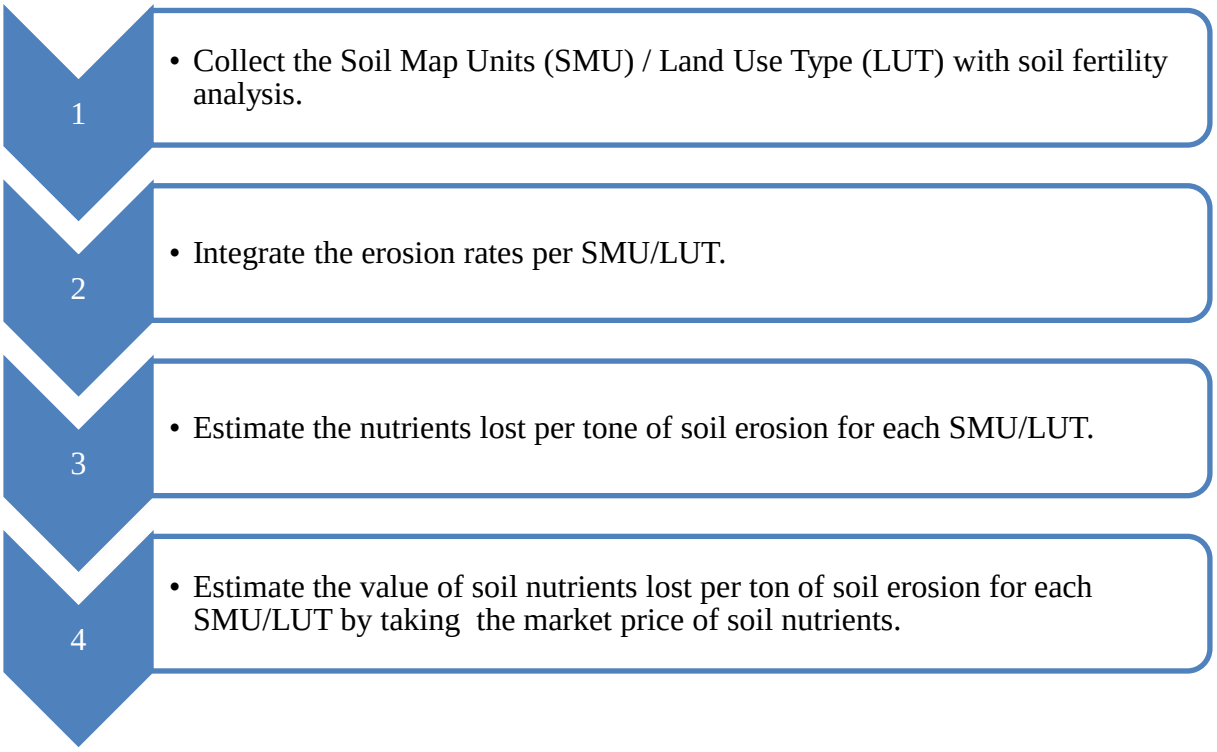
Operational Cost = cost of seeds, fertilizers, pesticides. Cost of human and bullock labour, cost of machinery, cost of irrigation water + interest on working capital.
Gross returns = Yield (Quintals/hectare)*Price (Rs/Quintal)
Net returns = Gross returns-Operational cost.
Benefit Cost Ratio = Net returns/Total cost.

Economic suitability classes: once each land use –land area combination has been assigned an economic value by the land evaluation, the question arises as to its 'suitability', that is, the degree to which it satisfies the land user. The FAO framework defines two suitability orders: 'S'(suitable if benefit cost ratio (BCR)>1) and 'N'(not suitable if (BCR<1), which are dived into five economic suitability classes:'S1'(highly suitable if BCR>3), 'S2'(suitable if BCR>2 and <3),'S3'(Marginally suitable if BCR >1 and <2), 'N1'(Not suitable for economic reasons but physically suitable) and 'N2'(not suitable for physical reasons). The limit between 'S3' and 'N1'must be at least at the point of financial feasibility (i.e. net returns, NPV, or IRR>0 and BCR>1). The other limits depend on social factors such as farm size, family size, alternative employment or investment possibilities and wealth expectations; these need to be specified for the Soil series.

Economic Valuation of Soil ecosystem services:

The replacement cost approach was followed for estimating the onsite cost of soil erosion, Market price method was followed for estimating the value of food and fodder production. Value transfer menthods was followed for estimating the value of water demand by different crops in the micro watershed.

Steps followed in Replacement cost methods for estimation of onsite cost of soil erosion



Chapter 4

RESULTS AND DISCUSSIONS

The demographic information shows that the household population dynamics encompasses the socioeconomic status of the farmer. For a rural family, the household size should be optimal to earn a comfortable livelihood through farm and non-farm wage earning. The total number of population in watershed area was 50, out of which 54 per cent were males and 46 per cent females. Average family size of the households is 5.0. Age is an important factor, which affects the potential employment and mobility status of respondents. The data on age wise distribution of farmers in the sample households indicated that majority of the farmers are coming under the age group of 18 to 30 years (36.0 %) followed by 30 to 50 years (28.0%) more than 50 years (18.0%) and 0 to18 years (18.0 %). Hence, in the study area in general, the respondents were of young and middle age, indicating thereby that the households had almost settled with whatever livelihood options they were practicing and sample respondents were young by age who could venture into various options of livelihood sources. Data on literacy indicated that 42 .0 per cent of respondents were literate and 58.0 per cent illiterate (Table 1).

Table 1: Human population among sample households in Machinahalli-1 Microwatershed

Particulars	**Units**	**Value**
Total human population in sample HHs	Number	50
Male	% to total Population	54.0
Female	% to total Population	46.0
Average family size	Number	5.0
Age group		
0 to 18 years	% to total Population	18.0
18 to 30 years	% to total Population	36.0
30 to 50 years	% to total Population	28.0
>50 years	% to total Population	18.0
Average age	Age in years	34.0
Education Status		
Illiterates	% to total Population	42.0
Literates	% to total Population	58.0
Primary School (<5 class)	% to total Population	16.0
Middle School (6- 8 class)	% to total Population	12.0
High School (9- 10 class)	% to total Population	12.0
Others	% to total Population	18.0

The ethnic groups among the sample farm households found to be 80 per cent belonging to other backward caste (OBC) and general caste are 20 percent (Table 2 and Figure 3). About 40 per cent of sample households are using liquefied petroleum gas and

60 per cent are using firewood as source of fuel for cooking. About 90 per cent of sample farmers are having electricity connection and 10 per cent of household having solar lamp. About 20 per cent are sample households having health cards. Majority (60 %) are having MNREGA job cards for employment generation. About 80 per cent of farm households are having ration cards for taking food grains from public distribution system. About 50.0 per cent of farm households are having toilet facilities.

Table 2: Basic needs of sample households in Machinahalli-1 Microwatershed

Particulars	Units	Value
Social groups		
OBC	% of Households	80.0
General	% of Households	20.0
Types of fuel use for cooking		
Fire wood	% of Households	60.0
Gas	% of Households	40.0
Energy supply for home		
Electricity	% of Households	90.0
Solar Lamp	% of Households	10.0
Number of households having Health card		
Yes	% of Households	20.0
No	% of Households	80.0
MGNREGA Card		
Yes	% of Households	60.0
No	% of Households	40.0
Ration Card		
Yes	% of Households	80.0
No	% of Households	20.0
Households with toilet		
Yes	% of Households	50.0
No	% of Households	50.0
Drinking water facilities		
Tube Well	% of Households	60.00
Tank	% of Households	40.00

The data collected on the source of drinking water in the study area is presented in Table 2. Majority of the sample respondents are having tube well (60.0 %) source for water supply for domestic purpose and 40.0 per cent of tank source.

The data on migration in Machinahalli-1 micro-watershed is given in Table 3. It indicated that around 2.0 per cent of samples households were migrated. The average distance travelled for seeking employment is 225 km.

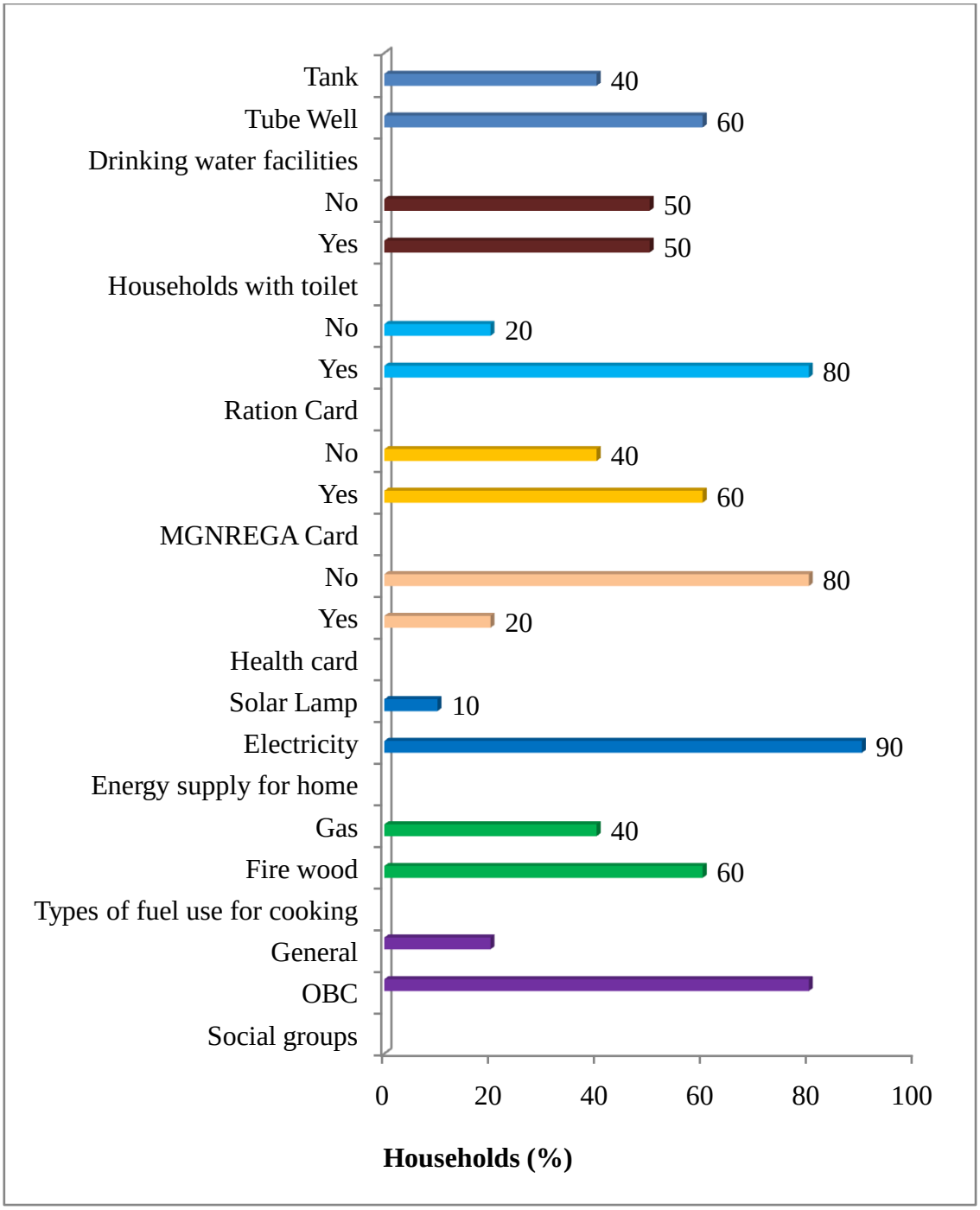


Figure 3: Basic needs of sample households in Machinahalli-1 Microwatershed

Table 3: Migration details among the sample households in Machinahalli-1 micro-watershed

Particulars	**Value**
% of households showing migration	2.0
% of persons migrating	10.0
No. of months migrated in a year	6.0
Average Distance of migration(Km)	225.0
Nature of job (%)	
Job/wage/work	100.0

The occupational pattern (Table 4) among sample households shows that agriculture labour is the main occupation around 38.0per cent of farmers followed by subsidiary occupations like 56 per cent of agriculture labour and govt service (2.4 %). Private Service is the main occupation was 4.0 per cent.

Table 4: Occupational pattern in sample population in Machinahalli-1 Microwatershed

Occupation		**% to total**
Main	**Subsidiary**	
Agriculture	Agriculture	38
	Agriculture labour	56
	Govt. service	2.0
Private service		4.0
Grand Total		100
Family labour availability		**Man days/month**
Male		47.5
Female		31.1
Total		78.6

The important assets especially with reference to domestic assets were analyzed and are given in Table 5 and Figure 4. The important domestic assets possessed by all categories of farmers are television (100 %) followed by mobile phones (100 %), mixer/grinder (70%), motorcycle (20 %), bicycle (20 %) and auto (10 %). The average value of domestic assets is around Rs. 34707 per households.

Table 5: Domestic assets among the sample households in Machinahalli-1 Microwatershed

Particulars	**% of households**	**Average value in Rs**
Auto	10.0	150000
Bicycle	20.0	3000
Mixer/grinder	70.0	3143
Mobile Phone	100.0	3400
Motorcycle	20.0	42500
Television	100	6200
Average Value	34707	

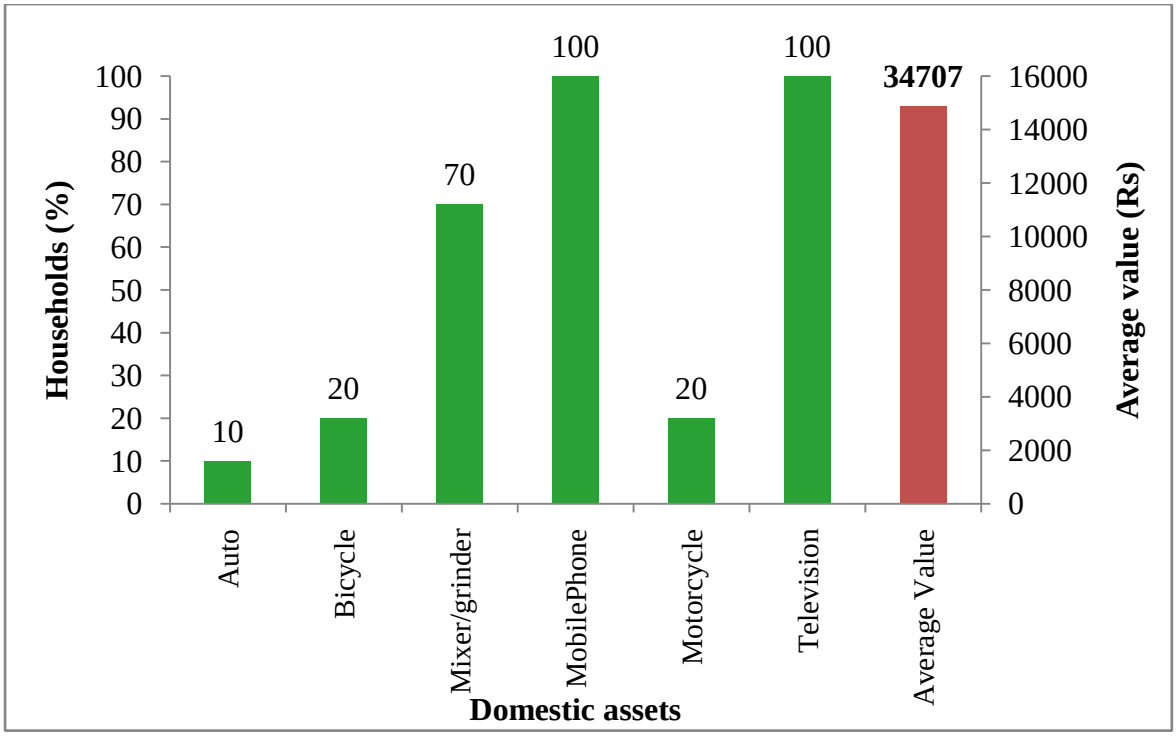


Figure 4: Domestic assets among the sample households in Machinahalli-1 Microwatershed

The most popularly owned farm equipments were sickles, plough, cattle shed; pump sets, chaff cutter, bullock cart, sprayer and thresher. Plough and sickle were commonly present in all the sampled farmers; these were primary implements in agriculture. The per cent of households owned plough (40 %) followed by bullock cart (30 %), sprayer (20 %) power tiller (10 %), seed cum fertilizer (10 %), tractor (10 %) and weeder (10 %) was found highest among the sample farmers. The average value of farm assets is around Rs 80279 per households (Table 6 and Figure 5).

Table 6: Farm assets among samples households in Machinahalli-1 Microwatershed

Particulars	% of households	Average value in Rs
Bullock cart	30.0	20000
Plough	40.0	1550
Power tiller	10.0	20000
Seed cum fertiliser drill	10.0	15000
Sprayer	20.0	5000
Tractor	10.0	500000
Weeder	10.0	400
Average Value	80279	

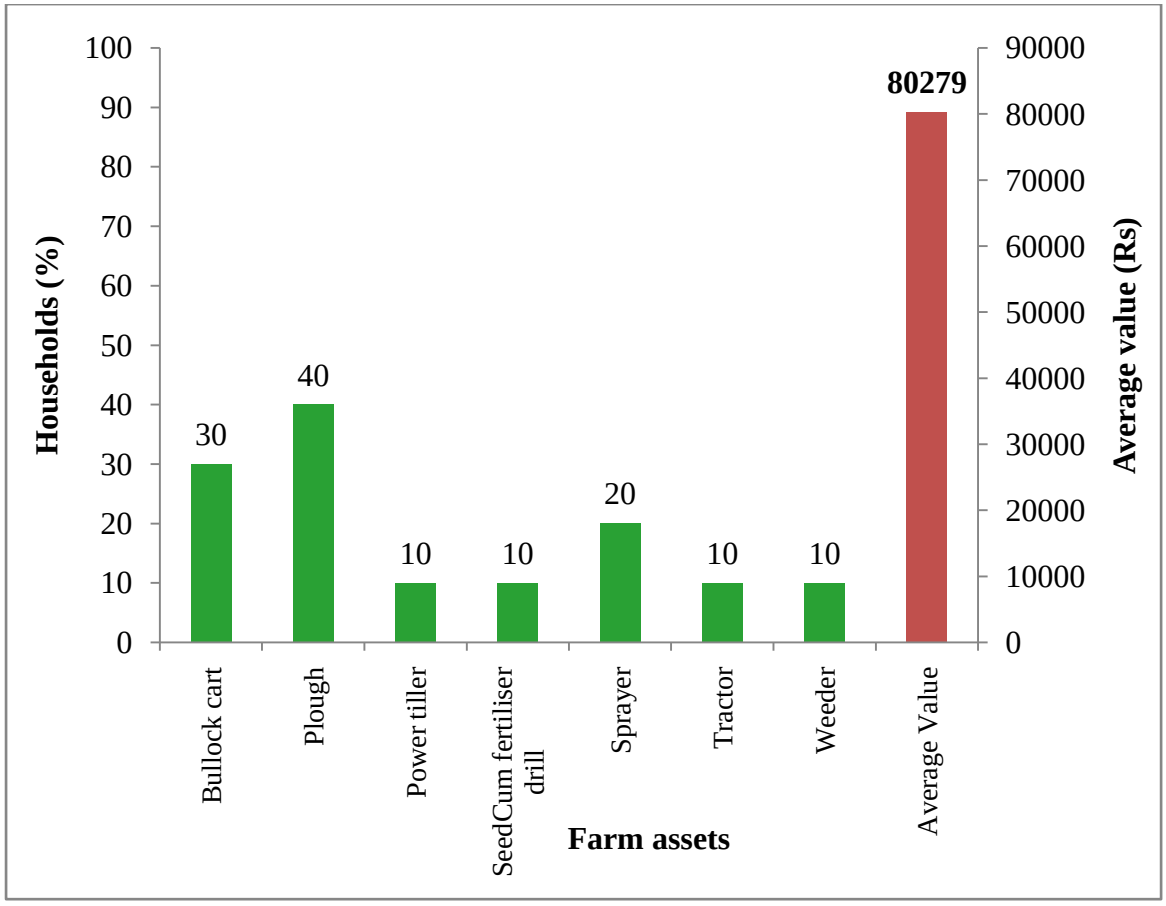


Figure5: Farm assets among samples households in Machinahalli-1 Microwatershed

Livestock is an integral component of the conventional farming systems (Table 7 and Figure 6). The livestock population is among bullocks (40 %), local dry cow (30 %), sheep's (20 %) and local milching cow (10 %). The average livestock value was Rs 24458 per households.

Table 7: Livestock assets among sample households in Machinahalli-1 micro-watershed

Particulars	% of livestock population	Average value in Rs
Local Dry Cow	30.0	10333
Local Milching Cow	10.0	15000
Bullocks	40.0	67500
Sheeps	20.0	5000
Average	24458	

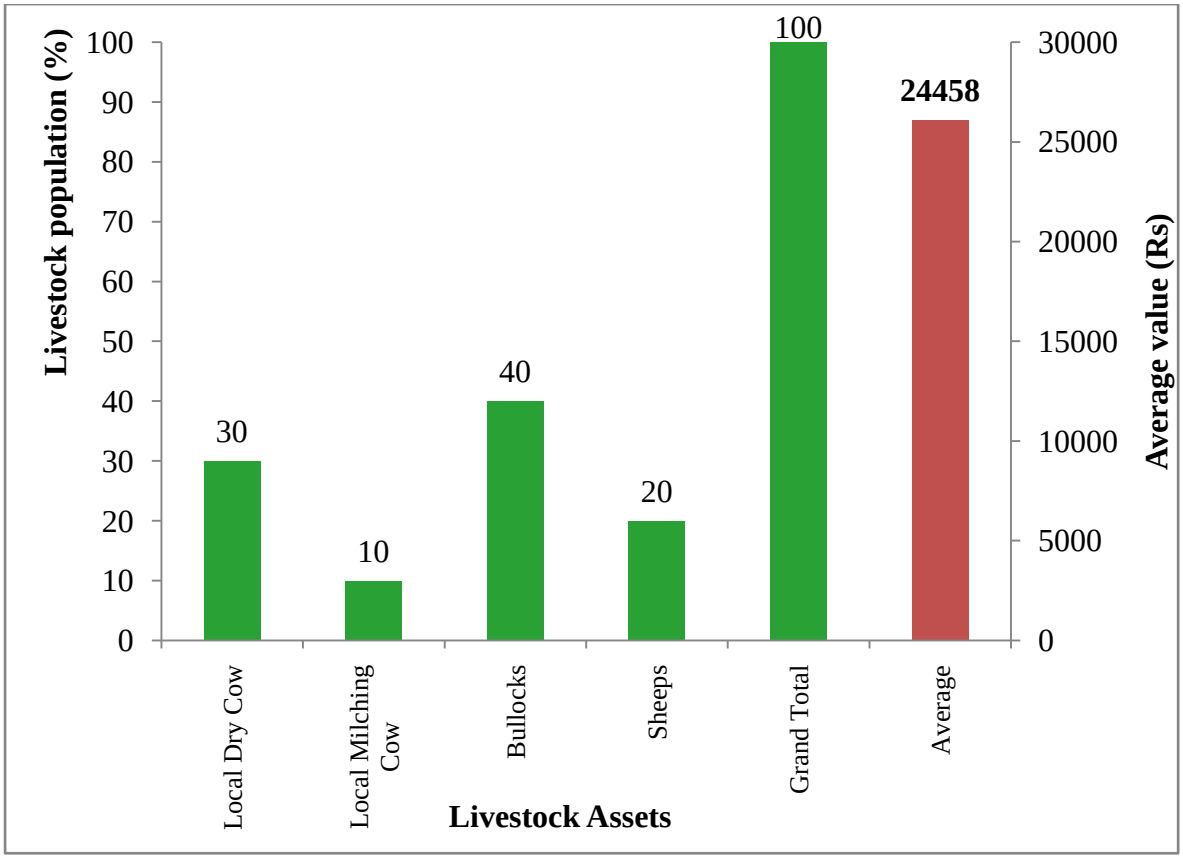


Figure 6: Livestock assets among sample households in Machinahalli-1 micro-watershed

Average milk produced in sample households is 300 litters/ annum. Among the farm households, sorghum, bajra and maize are the main crops for domestic food and fodder for animals. About 1960 kg /ha of average fodder is available per season for the livestock feeding (Table 8).

Table 8: Milk produced and fodder availability of sample households in Machinahalli-1 Microwatershed

Name of the Livestock	**Ltr./Lactation/animal**
Local Milching Cow	300
Average Milk Produced	300
Fodder produces	**Fodder yield (kg/ha.)**
Maize	1931
Groundnut	2018
Average fodder availability	1960
Livestock having households (%)	63.0
Livestock population (Numbers)	113

A woman participation in decision making is in this micro-watershed is presented in Table 9. Around 80 per cent women earning for her family requirement and 77.8 per cent of women taking decision in her family and agriculture related activities.

Table 9: Women empowerment of sample households in Machinahalli-1 Microwatershed % to Grand Total

Particulars	Yes	No
Women participation in local organization activities	0.0	100.0
Women elected as panchayat member	0.0	100.0
Women earning for her family requirement	80.0	20.0
Women taking decision in her family and agriculture related activities	77.8	22.2

The food intake in terms of kilo calorie (kcal) per person per day was calculated and presented in the Table 10 and Figure 7. More quantity of cereals is consumed by sample farmers which accounted for 1060 kcal per person. The other important food items consumed was followed by pulses 247.8 kcal, cooking oil 221.9 kcal, milk 120.7 kcal, egg 56.3 kcal vegetables 45.5 kcal and 8.1 kcal of meat in the sampled households, farmers were consuming less (1760.5 kcal) than NIN- recommended food requirement (2250 kcal).

Table 10: Per capita daily consumption of food among the sample households in Machinahalli-1 Microwatershed

Particulars	NIN recommendation (gram/ per day/ person)	Present level of consumption (gram/ per day/ person)	Kilo Calories /day/person
Cereals	396	311.8	1060.3
Pulses	43	72.3	247.8
Milk	200	185.7	120.7
Vegetables	143	189.5	45.5
Cooking Oil	31	38.9	221.9
Egg	0.5	37.5	56.3
Meat	14.2	5.4	8.1
Total	**827.7**	**841.0**	**1760.5**
Threshold of NIN recommendation		827 gram*	2250 Kcal*
% Below NIN		90.0	80.0
% Above NIN		10.0	20.0

Note: * day/person

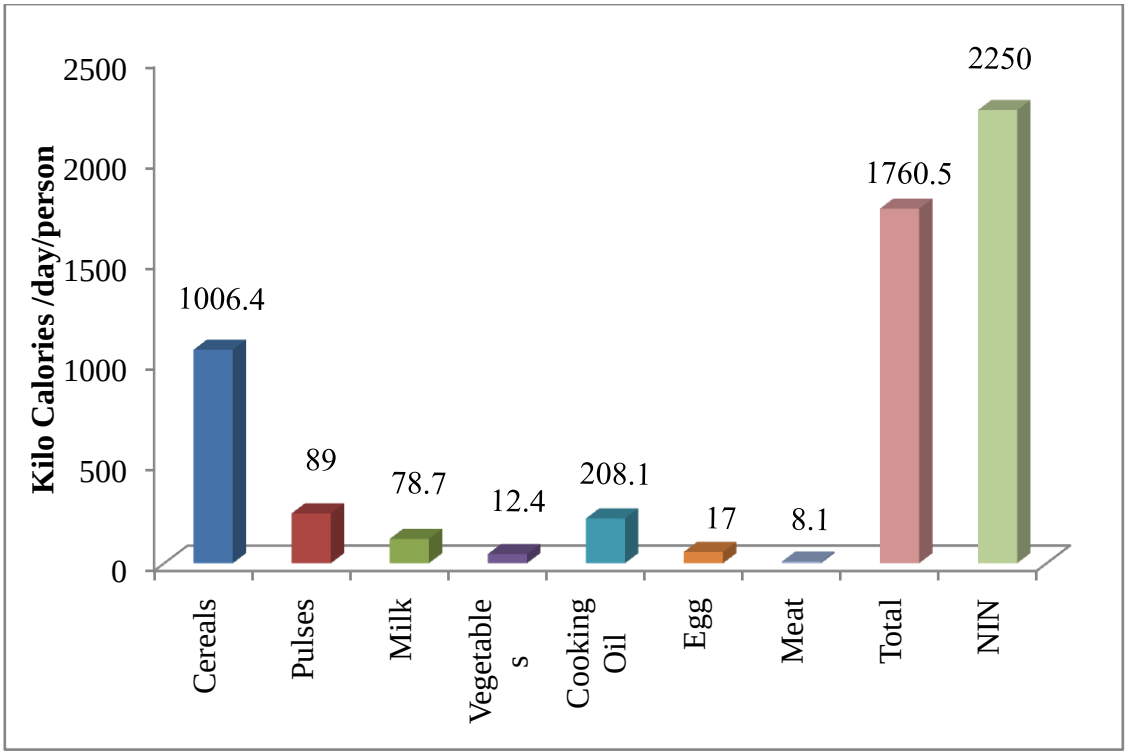


Figure 7: Per capita daily consumption of food among the sample households in Machinahalli-1 Microwatershed

Annual income of the sample HHs: The average annual household income is around Rs 16091.7 Major source of income to the farmers in the study area is from crop production (Rs 11286 followed by livestock (Rs. 3390). The income from Non farm income was very low at Rs. 1416. The monthly per capita income is Rs.286, which is less than the threshold monthly income of Rs 975 for considering above poverty line. Due to the fact that erratic rainfall and shortage of water, farmers are diverting from crop production activities to enable the household for a comfortable livelihood. The incomes from the other aforesaid sources are very meagre (Table 11).

Table 11: Annual average income of HHs from various sources in Machinahalli-1 Microwatershed

Particulars	**Income ***
Nonfarm income (Rs)	1416 (10)
Livestock income (Rs)	3390 (10)
Crop Production (Rs)	11286 (100)
Total Annual Income (Rs)	***16091***
Average monthly per capita income (Rs)	268
Threshold for Poverty level (Rs 975 per month/person)	
% of households below poverty line	90.0
% of households above poverty line	10.0

* Figure in the parenthesis indicates % of Households

The average annual expenditure of farm households indicated that farmers in the study area spend highest on food (Rs. 43824) followed by education, health, clothing, and social function. Now a day's education is most important among all of us. In today's competitive world, education is a necessity for man after food, clothing, and shelter. It is the only fundamental way by which a desired change in the society can happen. The average per capita monthly expenditure is around Rs 1124 and around 10 per cent of farm households are above poverty line (Table 12 and Figure 8).

Table 12: Average annual expenditure of sample HHs in Machinahalli-1 Microwatershed

Particulars	Value in Rupees	Per cent
Food	43824	65.0
Education	8500	12.6
Clothing	4300	6.4
Social functions	3300	4.9
Health	7500	11.1
Total Expenditure (Rs/year)	67424	100.0
Monthly per capita expenditure (Rs)	1124	

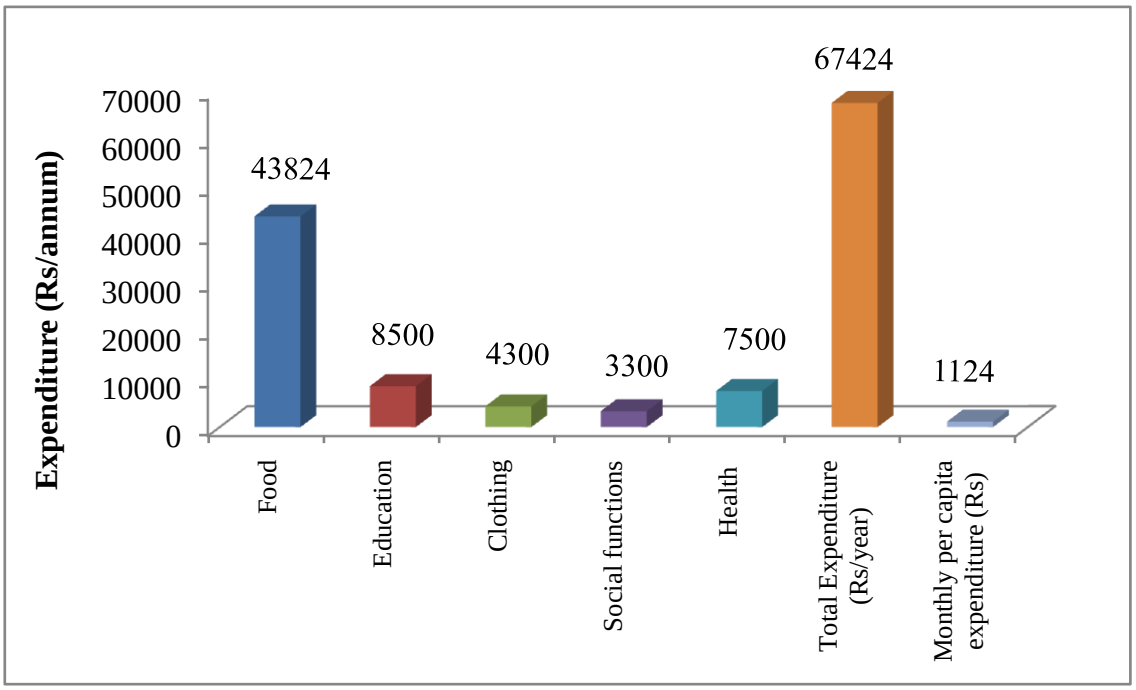


Figure8: Average annual expenditure of sample HHs in Machinahalli-1 Microwatershed

Land use: The total land holding in the Machinahalli-1 micro-watershed is 12.5 ha (Table 13). Of which 8.5 ha is rain fed land 3.9 ha is irrigated land. The average land holding per household is worked out to be 1.3 ha.

Table 13: Land use among samples households in Machinahalli-1 Microwatershed

Particulars	Per cent	Area in ha
Irrigated land	31.7	3.9
Rain fed Land	68.3	8.5
Fallow Land	0.0	0.0
Total land holding	100.0	12.5
Average land holding	1.3	

In the micro-watershed, the prevalent present land uses under perennial plants are coconut trees (50.8 %) followed by neem trees (41.3 %), banyan trees (6.3 %) and other trees (1.6 %) (Table14).

Table 14: Number of trees/plants covered in sample farm households in Machinahalli-1 Microwatershed

Particulars	Numbers	Per cent
Banyan tree(Alada)	4	6.3
Coconut	32	50.8
Neem trees	26	41.3
other	1	1.6
Grand Total	63	100.0

The land use decisions are usually based on experience of farmers, tradition, expected profit, personal preferences, resources and social requirements. The present dominant crops grown in dry lands in the study area were by maize (29.6 %) followed by cotton (13.9 %), groundnut (9.8 %), onion (7.2 %) and sunflower (3.3 %) which are taken during kharif season and maize (21 %), groundnut (11.1 %) and onion (4.03 %) during Rabi season respectively. The cropping intensity was 157 per cent (Table 15 and Figure 9).

Table 15: Present cropping pattern and cropping intensity in Machinahalli-1 Microwatershed % to Grand Total

Crops	Kharif	Rabi	Grand Total
Maize	29.6	21.0	50.8
Groundnut	9.8	11.1	20.8
Cotton	13.9	0	13.9
Onion	7.2	4.03	11.2
sunflower	3.3	0	3.3
Grand Total	***63.6***	***36.4***	***100.0***
Cropping intensity (%)	157		

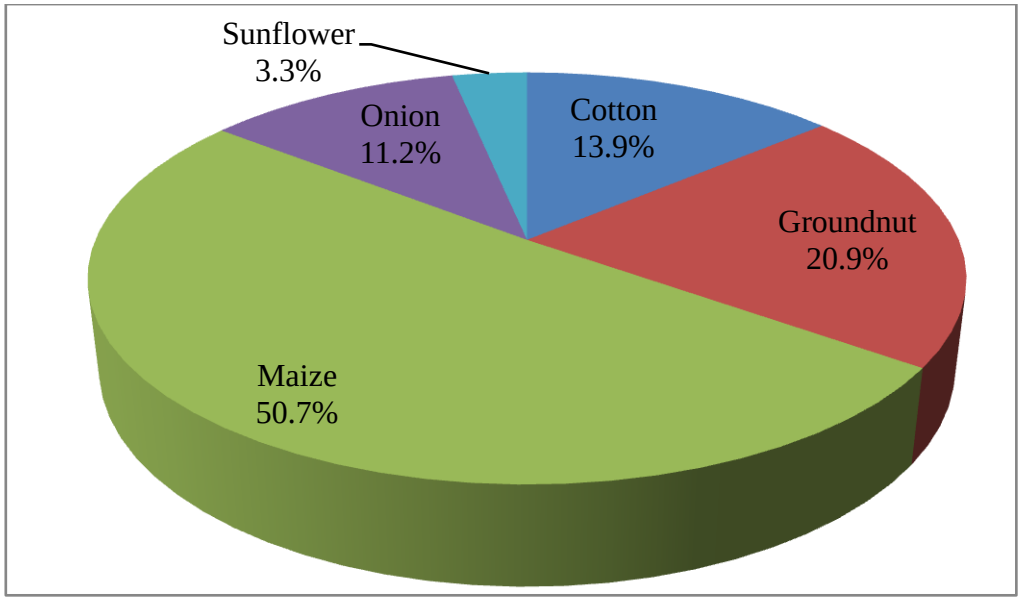


Figure 9: Present cropping pattern in Machinahalli-1 Microwatershed

Economic land evaluation

The main purpose of economic land evaluation in the watershed is to identify the existing production constraints and propose the potential/alternate options for agro-technology transfer and for bridging the adoption and yield gap.

In Machinahalli-1 Microwatershed, 11 soil series are identified and mapped (Table 16). The distribution of major soil series are Mahalingapuratanda covering an area around 159.6 ha (22.4%) followed by Kaggalipura 155.1 ha (21.8 %), Yelisirunj 45.38 ha (6.4 %), Attikatti 44.6 ha (6.3 %), Jelligeri 44.2 ha (6.2 %), Kethanapura 43.5 ha (6.1 %), Nabhapur 39.5 ha (5.5 %), Thammadahalli 16.2 ha (2.3 %), Balapur 16.0 ha (2.2 %), Lakkur 7.2 ha (1.0 %) and Mukhadahalli 3.5 ha (0.5 %).

Table 16: Distribution of soil series in Machinahalli-1 Microwatershed

Soil No	Soil Series	Mapping unit description	Area in ha (%)
1	ATT	Attikatti soils are moderately shallow (50-75 cm), well drained, have dark brown to very dark brown clayey soils occurring on very gently sloping uplands under cultivation	44.6 (6.3)
2	BPR	Balapur soils are deep (100-150 cm), well drained, have dark reddish brown to dark red gravelly sandy clay to clay soils occurring on very gently to gently sloping uplands under cultivation	16.0 (2.2)
3	JLG	Jelligeri soils are moderately deep (75-100 cm), moderately well drained, very dark brown to dark brown and black cracking clay soils occurring on very gently sloping uplands	44.2 (6.2)

		under cultivation	
4	KGP	Kaggalipura soils are shallow (25 - 50 cm), well drained, have brown to dark reddish brown sandy clay loam to sandy clay soils occurring on very gently sloping uplands under cultivation	155.1 (21.8)
5	KTP	Kethanapura soils are moderately shallow (50-75 cm), well drained, have dark reddish brown gravelly sandy loam soils occurring on very gently to gently sloping uplands under cultivation	43.5 (6.1)
6	LKR	Lakkur soils are moderately shallow (50-75 cm), well drained, have reddish brown to dark red gravelly sandy clay loam to sandy clay red soils occurring on nearly level to gently and moderately sloping uplands under cultivation	7.2 (1.0)
7	MKH	Mukhadahalli soils are moderately shallow (50-75 cm), well drained, have dark brown to reddish brown gravelly sandy clay loam soils occurring on very gently to gently sloping uplands under cultivation	3.5 (0.5)
8	MPT	Mahalingapur Tanda soils are deep (100-150 cm), moderately well drained, have very dark brown to very dark greyish brown cracking clay soils occurring on very gently sloping uplands under cultivation	159.6 (22.4)
9	NPT	Nabhapur Tanda soils are shallow (25-50 cm), well drained, have very dark brown to very dark gray calcareous clay soils occurring on very gently sloping uplands under cultivation	39.5 (5.5)
10	TDH	Thammadahalli soils are moderately shallow (50 – 75 cm), well drained, have brown to very dark brown and dark reddish brown sandy loam to clay loam soils occurring on nearly level to gently sloping uplands under cultivation	16.2 (2.3)
11	YSJ	Yelisirunj soils are shallow (25-50 cm), well drained, have very dark brown to very dark greyish brown clay soils occurring on very gently sloping uplands under cultivation	45.4 (6.4)
Rock outcrops			123.6 (17.4)
Habitation			13.5 (1.9)

Present cropping pattern on different soil series are given in Table 17. Crops grown on Nabhapur Tanda soils are maize and onion. Groundnut, maize, onion and sunflower on Ravanaki soils are grown. Bajra, maize and sunflower are grown on Kutegoudanahundi soils. Cotton, maize and sunflower on Dambarahalli soils are grow. Maize and cotton on Yelisirunj and Kethanapura soils are growing respectively. Maize and onion on Attikatti soils is grow. Maize on Jelligeri soils is growing. Maize and groundnut on Mahalingapur Tanda soils can grow.

Table 17: Cropping pattern on major soil series in Machinahalli-1 Microwatershed

(Area in per cent)

Soil Series	Soil Depth	Crops	Dry		Irrigated		Grand Total
			Kharif	Rabi	Kharif	Rabi	
Nabhapur Tanda	Shallow (25-50 cm)	Maize	0.0	0.0	62.5	0.0	62.5
		Onion	0.0	0.0	37.5	0.0	37.5
Yelisirunj	Shallow (25-50 cm)	Maize	0.0	100.0	0.0	0.0	100.0
Kaggalipura	Shallow (25-50 cm)	Groundnut	0.0	1.5	0.0	29.9	44.9
		Maize	0.0	0.0	26.2	0.0	26.2
		Onion	0.0	0.0	0.0	15.7	15.7
		Sunflower	0.0	0.0	13.1	0.0	13.1
Kethanapura	Moderately shallow (50-75 cm)	Cotton	100.0	0.0	0.0	0.0	100.0
Attikatti	Moderately shallow (50-75 cm)	Maize	67.0	0.0	0.0	0.0	66.7
		Onion	33.0	0.0	0.0	0.0	33.3
Jelligeri	Moderately deep (75-100 cm)	Maize	0.0	100.0	0.0	0.0	100.0
Mahalingapur Tanda	Deep (100-150 cm)	Groundnut	42.9	0.0	0.0	0.0	42.9
		Maize	57.1	0.0	0.0	0.0	57.1

Land is used for agricultural use for growing cereals, pulse, oilseeds and commercial crops. The soil/ land potential are measures in terms of physical yield and net income. The alternative land use options for each micro-watershed are given below (Table 18).

Table 18: Alternative land use options for different size group of farmers (Benefit Cost Ratio) in Machinahalli-1 Microwatershed.

Soil Series	Small Farmers	Medium Farmers
NPT	Maize (1.6)& Onion (1.8)	
YSJ	Maize (1.3)	
KGP	Groundnut (1.2),Maize (1.3) Onion (1.0)& Sunflower (1.0)	
ATT	Maize (1.1)&Onion (1.2)	
KTP	Cotton (1.4)	
JLG	Maize (1.3)	
MPT		Groundnut (1.2)&Maize (1.1)

The productivity of different crops grown in Machinahalli-1 micro-watershed under different soil series and potential yield of the crops is given in Table 19.

The data on cost of cultivation and benefit cost ratio (BCR) of different crops is given in Table 19. The total cost of cultivation in study area for groundnut cultivation range between Rs.43075/ha in KGP soil (with BCR of 1.2) and Rs.26129/ha in MPT soil (with BCR of 1.23), maize range between Rs.37780/ha in KGP soil (with BCR of 1.27) and Rs.20714/ha in MPT soil (with BCR of 1.10), onion cost of cultivation range between is Rs 61558/ha in NPT soil (with of 1.00) and Rs 55633 in ATT soil (with BCR of 1.20), sunflower cost of cultivation in KGP soil is Rs 39049/ha (with BCR of 1.00) and cotton cost of cultivation in KTP soil Rs. 24320/ha (with BCR of 1.43).

Table 19: Economic evaluation and bridging yield gap for different crops in Machinahalli-1 Microwatershed

Particulars	KGP (25-50 cm)				NPT (25-50 cm)		YSJ (25-50 cm)	ATT (50-75 cm)		KTP (50-75 cm)	JLG (75-100 cm)	MPT (100-150 cm)	
	Ground nut	Maize	Onion	Sun flower	Maize	Onion	Maize	Maize	Onion	Cotton	Maize	Ground nut	Maize
Total cost (Rs/ha)	43075	37780	61558	39049	37067	55831	22288	30922	55633	24320	23886	26129	20714
Gross Return (Rs/ha)	49292	47795	61750	38903	60762	98800	28951	34827	66690	34789	30681	32028	22848
Net returns (Rs/ha)	6217	10014	192	-146	23695	42969	6663	3905	11057	10469	6795	5898	2134
BCR	1.15	1.27	1.00	1.00	1.64	1.77	1.30	1.13	1.20	1.43	1.28	1.23	1.10
Farmers Practices (FP)													
FYM (t/ha)	3.8	3.8	4.2	2.5	3.8	4.2	0.0	2.5	5.0	1.8	1.6	1.7	1.9
Nitrogen (kg/ha)	71.0	76.3	151.0	76.3	145.8	145.8	73.1	123.1	123.1	76.6	70.8	69.1	69.1
Phosphorus (kg/ha)	58.9	68.1	113.5	68.1	101.5	101.5	70.1	118.1	118.1	78.3	67.6	53.1	53.1
Potash (kg/ha)	14.0	10.6	17.7	10.6	24.8	24.8	18.9	31.9	31.9	15.0	13.4	12.4	12.4
Grain (Qtl/ha)	9.3	31.3	62.5	8.8	50.0	125.0	18.5	22.5	62.5	11.7	19.7	7.5	18.8
Price of Yield (Rs/Qtl)	5000	1500	1000	4500	1200	800	1500	1500	1000	3000	1500	4100	1200
Soil test based fertilizer Recommendation (STBR)													
FYM (t/ha)	8.6	8.6	29.6	6.6	8.6	29.6	8.6	8.6	29.6	12.4	8.6	8.6	8.6
Nitrogen (kg/ha)	18.5	92.6	92.6	41.4	92.6	92.6	123.5	123.5	123.5	148.2	123.5	24.7	123.5
Phosphorus (kg/ha)	77.2	77.2	92.6	74.1	61.8	74.1	77.2	61.8	74.1	74.1	77.2	77.2	77.2
Potash (kg/ha)	30.9	32.1	123.5	37.1	24.1	92.6	32.1	32.1	123.5	55.6	32.1	23.2	24.1
Grain (Qtl/ha)	17.3	84.0	247.0	16.5	84.0	247.0	84.0	84.0	247.0	17.3	84.0	17.3	84.0
% of Adoption/yield gap (STBR-FP) / (STBR)													
FYM (%)	55.6	56.6	85.9	62.0	56.6	85.9	100.0	71.1	83.1	85.7	81.8	80.7	78.3
Nitrogen (%)	-283.3	17.7	-63.1	-84.3	-57.4	-57.4	40.8	0.3	0.3	48.3	42.7	-179.6	44.1
Phosphorus (%)	23.6	11.7	-22.6	8.1	-64.3	-36.9	9.2	-91.3	-59.4	-5.7	12.4	31.2	31.2
Potash (%)	54.7	66.9	85.7	71.3	-2.9	73.2	41.1	0.7	0.0	73.1	58.4	46.5	0.0
Grain (%)	46.1	62.8	74.7	46.9	40.5	49.4	77.9	73.2	74.7	32.1	76.6	56.6	77.7
Value of yield and Fertilizer (Rs)													
Additional Cost (Rs/ha)	5319	5920	25968	4460	2495	24988	9826	3674	24540	12074	8502	7720	8716
Additional Benefits (Rs/ha)	39849	79095	184500	34725	40776	97600	98151	92220	184500	16659	96489	40139	78276
Net change Income (Rs/ha)	34531	73175	158532	30265	38281	72612	88325	88546	159960	4584	87987	32419	69560

The data on FYM, Nitrogen, Phosphorus and Potash application by the farmers to different crops and recommended FYM for different crops is given in Table 19. There is a huge gap between FYM application by farmers and recommended FYM in all the crops across the soils. There is a larger yield gap in crops grown across different soil series. Adequate knowledge about recommended package of practices is the pre-requisite for their use in cultivation of crops. It is a fact that, recommended practices are major contributing factors to yield. Inadequate knowledge about recommended practices leads to their improper adoption. Strengthening of extension services by concerned agency is required to increase adoption of recommended cultivation practices and ultimately reducing the gap. By adopting soil-test fertiliser recommendation, there is scope to increase yield and income to a maximum of Rs 159960 in onion and a minimum of Rs 4584 in cotton cultivation.

Economic valuation of Ecosystem Services (ES) was aimed at combining use and non-use values to determine Total Economic Value (TEV) of ES. Ecosystem Services (ES) were valued based on their annual flow or utilization in common monetary units, Rs/year. The valuation of ES was based on market price in 2017 or market cost approaches whichever is applicable, and in other cases on value or benefit transfer from previous valuation studies.

The onsite cost of different soil nutrients lost due to soil erosion is given in Table 20 and Figure 10. The average value of soil nutrient loss is around Rs 1985 per ha/year. The total cost of annual soil nutrients is around Rs 1137336 per year for the total area of 711.8 ha.

Table 20: Estimation of onsite cost of soil erosion in Machinahalli-1 Microwatershed

Particulars	Quantity(kg)		Value (Rs)	
	Per ha	Total	Per ha	Total
Organic matter	289.2	165706	1821.9	1043948
Phosphorus	0.2	105	8.1	4624
Potash	3.6	2054	71.7	41078
Iron	0.1	34	2.8	1627
Manganese	0.2	112	53.6	30732
Cupper	0.03	19	18.9	10806
Zinc	0.01	6	0.5	258
Sulphur	0.2	100	6.1	4008
Boron	0.01	6	0.4	254
Total	383	168143	1984.9	1137336

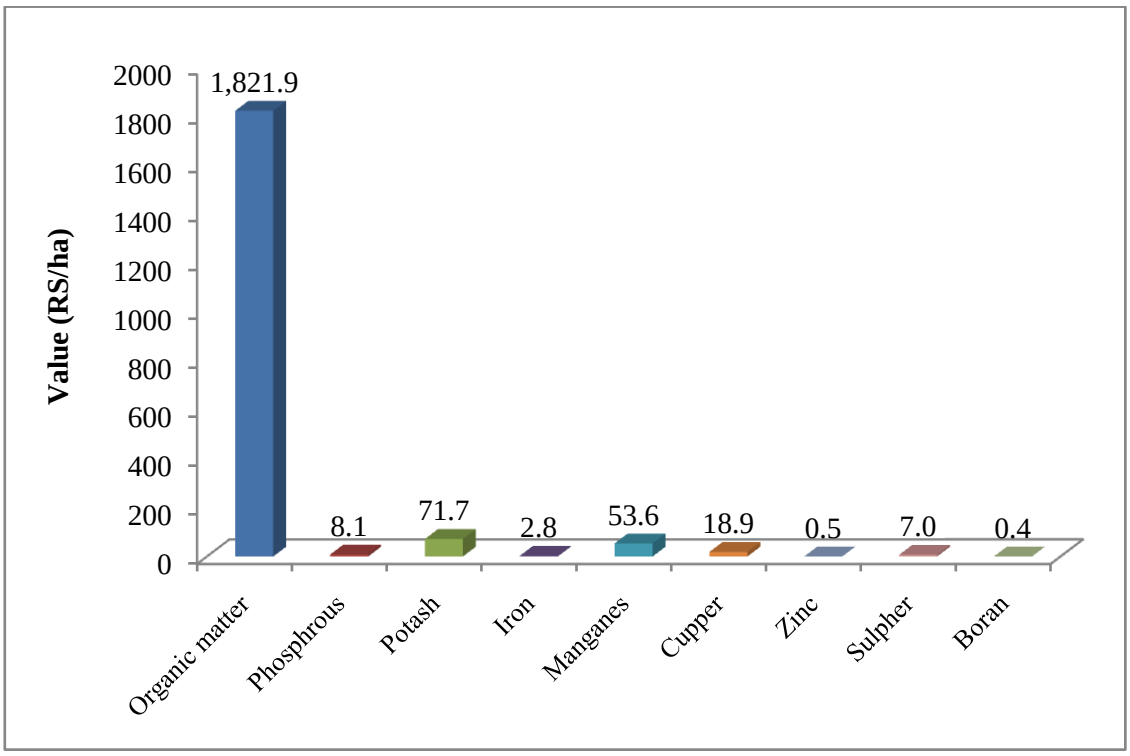


Figure 10: Estimation of onsite cost of soil erosion in Machinahalli-1 Microwatershed

The average value of ecosystem service for food grain production is around Rs. 8160/ ha/year (Table 21 and Figure 11). Per hectare food grain production services is maximum in onion (Rs. 10469) followed by maize (Rs. 8271), groundnut (Rs. 3036) and sunflower is negative returns.

Table 21: Ecosystem services of food grain production in Machinahalli-1 Microwatershed

Production items	Crops	Area in ha	Yield (Qtl/ha)	Price (Rs/Qtl)	Gross Returns (Rs/ha)	Cost of Cultivation (Rs/ha)	Net Returns (Rs/ha)
Cereals	Maize	6.7	26.0	1400	37047	28776	8271
Oil seeds	Groundnut	2.6	9.0	4700	40462	37426	3036
	Sunflower	0.4	9.0	4500	38903	39049	-146
Vegetables	Onion	1.4	82.0	933	76844	57674	19170
Commercial Crops	Cotton	1.7	12.0	3000	34789	24320	10469
Average value		12.8	27.6	2906	45609	39617	8160

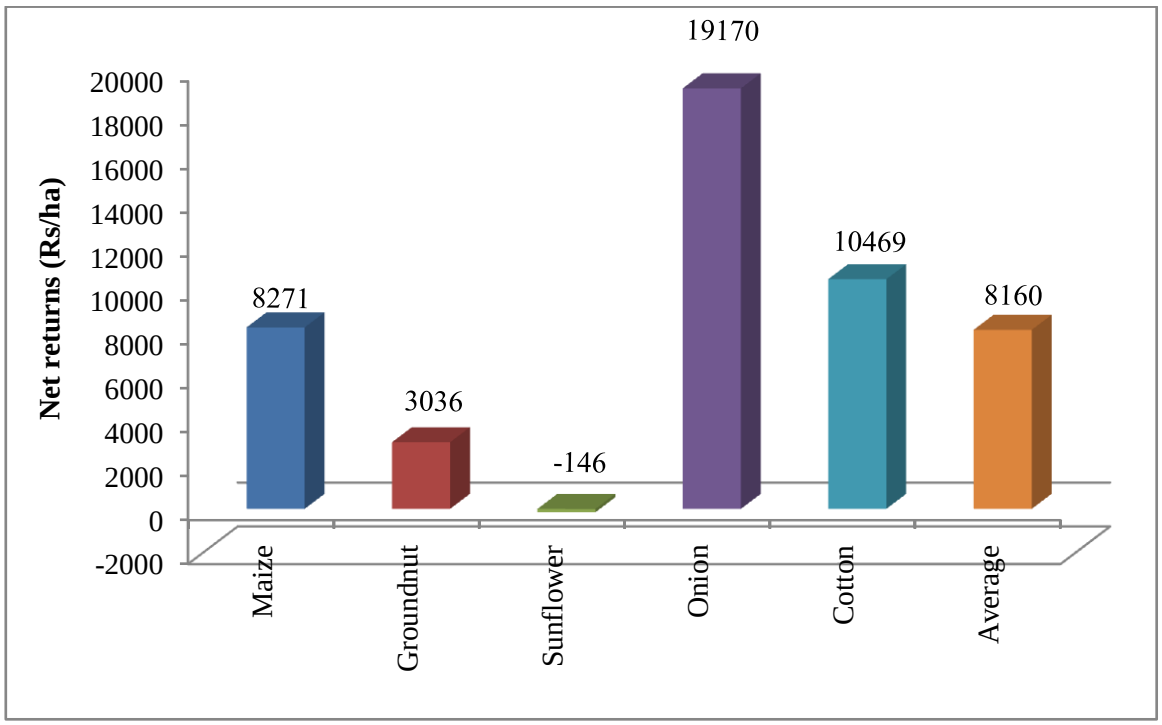


Figure 11: Ecosystem services of food grain production in Machinahalli-1 Microwatershed

The average value of ecosystem service for fodder production is around Rs 1473/ ha/year in maize (Table 22).

Table 22: Ecosystem services of fodder production in Machinahalli-1 Microwatershed

Production items	Crops	Area in ha	Yield (Qtl/ha)	Price (Rs/Qtl)	Net Returns (Rs/ha)
Cereals	Maize	6.7	1.8	800	1473

The water demand for production of different crops was worked out in arriving at the ecosystem services of water support to crop growth. The data on water requirement for producing one quintal of grain is considered for estimating the total value of water required for crop production. The per hectare value of water used and value of water was maximum (Table 23 and Figure 12) in cotton (Rs. 46721) followed by maize (Rs. 32336), sunflower (Rs. 29099), groundnut (Rs. 23950) and onion (Rs. 22395).

Table 23: Ecosystem services of water supply in Machinahalli-1 Microwatershed

Crops	Yield (Qtl/ha)	Virtual water (cubic meter) per ha	Value of Water (Rs/ha)	Water consumption (Cubic meters/Qtl)
Cotton	11.6	4672	46721	403
Groundnut	8.6	2395	23950	278
Maize	26.5	3234	32336	122
Onion	82.3	2239	22395	27
Sunflower	8.6	2910	29099	337
Average value	137.6	3090	30900	233

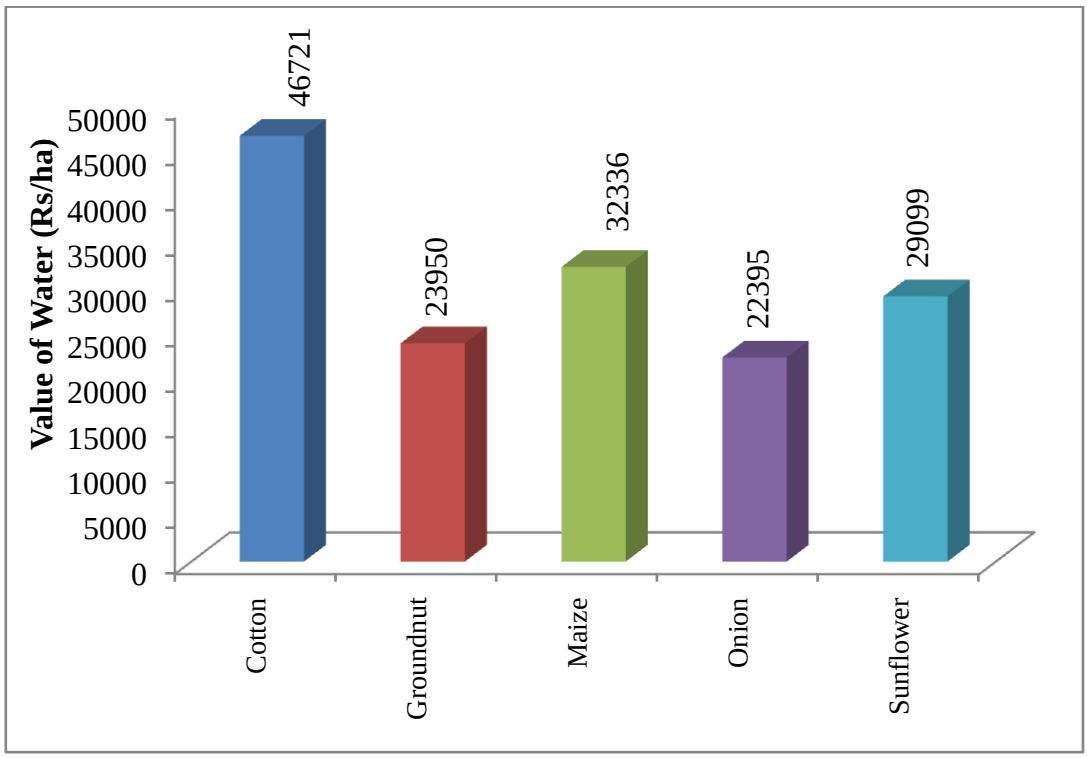


Figure 12: Ecosystem services of water supply in Machinahalli-1 Microwatershed

Table 24: Farming constraints related land resources of sample households in Machinahalli-1 Microwatershed

Sl.No	Particulars	Per cent
1	Less Rainfall	80.0
2	Lack of good quality seeds	10.0
3	Non availability Fertilizers	100.0
4	High Crop Pests & Diseases	10.0
5	Animal Pests & Diseases	20.0
6	Lack of transportation	20.0
7	Lack of storage	40.0
8	Damage of crops by Wild Animals	100.0
9	**Source of loan**	
	Money Leander	10.0
	Village merchants	90.0
10	**Market for selling**	
	Regulated	20.0
	Village market	80.0
11	**Sources of Agri-Technology information**	
	Newspaper	100.0

The main farming constraints in Machinahalli-1 micro-watershed to be found are less rainfall, lack of good quality seeds, non availability fertilizers, high crop pests & diseases, animal pests & diseases, lack of transportation, lack of storage, damage of crops by wild

animals and non availability of plant protection chemicals. Majority of farmers depend up on bank and money lender of the sources of loan for purpose of crop production. Farmers to sell the agriculture produce through village market, regulated and the farmers getting the agriculture related information on newspaper and television. Farmers reported that they are not getting timely support/extension services from the concerned development department (Table 24).

The findings of the study would be very much useful to the planners and policy makers of the study area to identify the irrationality in the existing production pattern and to suggest appropriate production plans for efficient utilization of their scarce resources resulting in increased net farm incomes and employment. The study also throws light on future potentialities of increasing net farm income and employment under different situations viz., with existing and recommended technology.